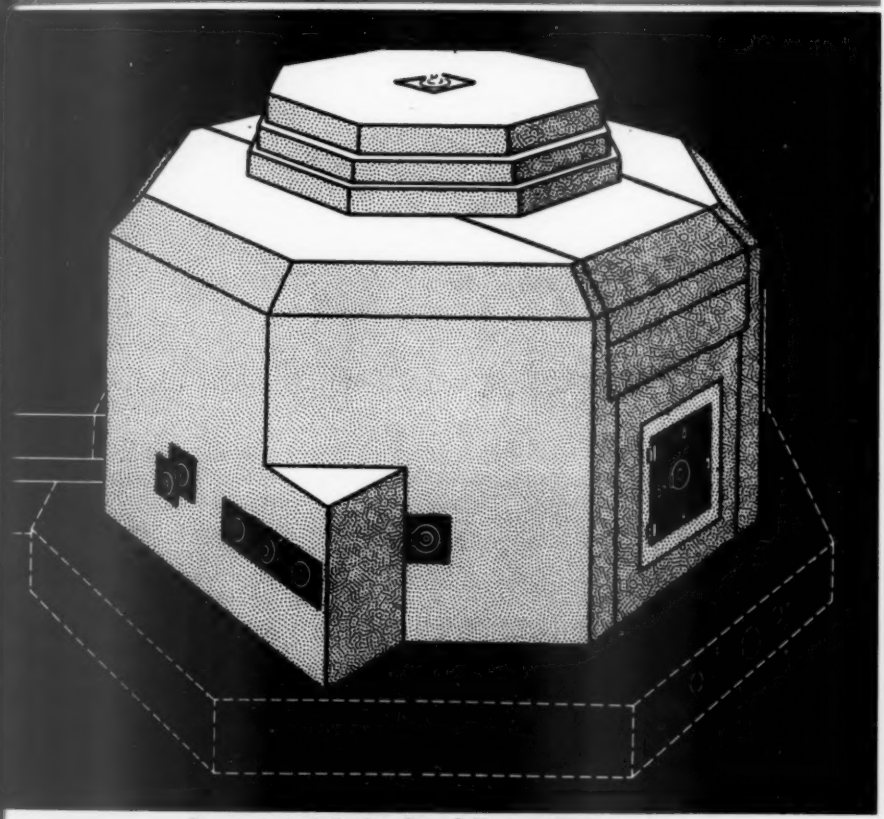
NUCLEONICS

UNIVERSITY
OF MICHIGAN
JAN 4 1951
ENGINEERING
LIBRARY

TECHNIQUES AND APPLICATIONS OF NUCLEAR SCIENCE AND ENGINEERING

December, 1950



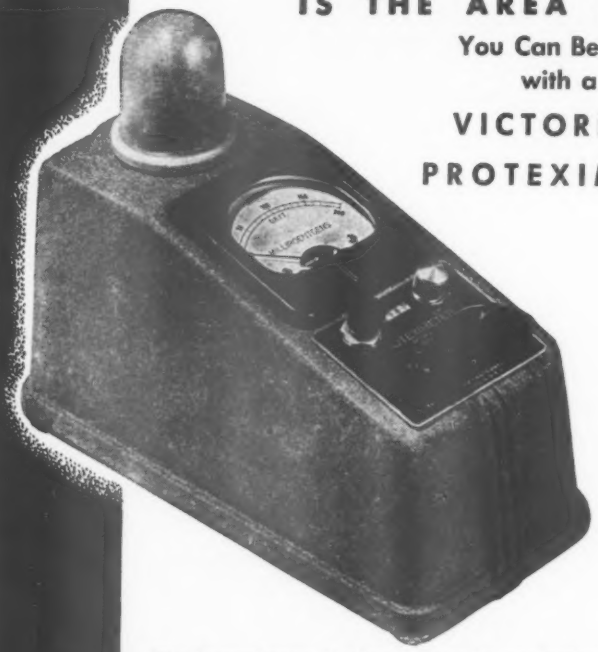
Proposed North Carolina State College reactor; see p. 5

A McGRAW-HILL PUBLICATION

IS THE AREA SAFE?

You Can Be Sure
with a

VICTOREEN
PROTEXIMETER



The Proteximeter is advantageous in monitoring scattered x radiation or gamma rays at any location adjacent to the radiation source. It measures such scattering accumulatively the quantity indicated visually on a calibrated meter scale.

The scale is calibrated in milliroentgens with full scale deflection 200 milliroentgens or 0.2 r, which is more than the accepted value for a daily tolerance dose. The externally mounted ionization chamber is hermetically sealed.

True, alpha particles do not penetrate very far . . . but they contaminate your laboratory just the same. Victoreen's Model 356 Alpha Meter is your answer to quick accurate detection and measurement.

INQUIRIES INVITED.

THE VICTOREEN INSTRUMENT CO.
5806 HOUGH AVENUE CLEVELAND 3, OHIO

NUCLEONICS

DECEMBER · 1950

Vol. 7, No. 6

Techniques and Applications of Nuclear Science and Engineering

Nuclear Reactor Project at North Carolina State College... 5
CLIFFORD K. BECK

Present State of Nuclear Physics... 15
URNER LIDDEL

Comparison of Geiger-Counter and Ion-Chamber Methods of Measuring Gamma Radiation... 21
W. K. SINCLAIR

Report of "Symposium on Mode of Action of Ionizing Radiations"... 26
ALMA HOWARD

Recent Applications of Neutron Diffraction... 31
A. H. WEBER

Radioisotopes in Pharmaceutical and Medical Studies—II... 40
D. L. TABERN, J. D. TAYLOR, and G. I. GLEASON

An End-Window Alpha Scintillation Counter for Low Counting Rates... 56
CLIFTON W. REED

Physical Considerations in Applying Cobalt-60 to Cancer Therapy... 63
G. W. CALLENDINE, Jr., J. L. MORTON, and W. G. MYERS

Adapting Glove Boxes to Gamma Work... 83

INDEX to Volume 7... 95

EDITORIAL.....2 BOOKS.....66 CROSS SECTIONS.....72
NUCLEONIC EVENTS.....76 PRODUCTS AND MATERIALS.....84

KEITH HENNEY, Editor • JEROME D. LUNTZ, Executive Editor

Ethel Pelzer, Associate Editor; C. J. Mosbacher, Jr., Asssistant Editor; S. D. Kirkpatrick, P. W. Swain, Consulting Editors; George B. Bryant, Jr., Gladys Montgomery, Washington Office; George C. Tenney, San Francisco Office; Russell F. Anderson, World News

BUSINESS DEPT.—H. W. MATEER, Publisher; WALLACE B. BLOOD, Manager; D. H. Miller, J. Girdwood, New York; Wm. S. Hodgkinson, New England; Warren W. Shew, Philadelphia; C. D. Wardner, Chicago; J. L. Phillips, Cleveland; J. W. Otterson, San Francisco; Carl W. Dysinger, Los Angeles; Ralph C. Maultsby, Atlanta; J. E. Blackburn, Jr., Director of Circulation

NUCLEONICS (with which is consolidated "Atomic Power" and "Atomic Engineering"), December 1950, Vol. 7, No. 6. Publication Office: 212 East York St., York, Pa., Editorial and Circulation Offices: 330 W. 42nd Street, New York 18, N. Y. Published monthly by McGraw-Hill Publishing Company, Inc. Entered as second class matter December 17, 1947, in the Post Office at York, Pa., under the act of March 3, 1879.

Copyright 1950 by McGraw-Hill Publishing Company, Inc. All rights reserved. Curtis W. McGraw, President; Willard Chevalier, Executive Vice President; Joseph A. Gerardi, Vice President and Treasurer; John J. Cooke, Secretary; Paul Montgomery, Senior Vice President, Publications Division; Ralph B. Smith, Editorial Director; Nelson Bond, Vice President and Director of Advertising; J. E. Blackburn, Jr., Vice President and Director of Circulation.

Allow at least ten days for change of address. All communications about subscriptions should be addressed to Director of Circulation, 330 West 42nd Street, New York 18, N.Y. Price per copy $1. Subscription rates: United States and U.S. Possessions $10 for 1 year, $16 for 2 years, $20 for 3 years. Canada, $15 for 1 year, $25 for 2 years, $30 for 3 years. Latin America $20 a year. All other countries $25 a year.

Where to Now?

Two STEPS taken by the U. S. Atomic Energy Commission within the past six weeks herald the opening of a new phase of the atomic energy field. On October 29, the AEC announced the authorization of the construction of the first non-AEC owned and operated nuclear reactor in this country. And on November 24, the scope of the new Declassification Guide, approved by the U. S., the United Kingdom, and Canada, was described [see p. 76].

These moves are quite definitely related. The non-AEC reactor, to be built by North Carolina State College at Raleigh [see p. 5 for a detailed description of this program by its director], will be a water boiler (the uranium fuel is in the form of a uranyl salt dissolved in water) designed to operate at a maximum power of ten kilowatts. The new Declassification Guide deals specifically with low-power-level reactors, making declassifiable such reactors in this country as the water boiler at Los Alamos and two reactors at Argonne.

A number of questions are raised by these two events. How will progress in reactor development be affected? What use are low-level reactors in research? In industry? In education? Is a significant change in AEC policy involved?

In this age, where laboratory "equipment" is becoming more and more expensive, low-flux, low-power reactors are primarily useful as research tools, but are extremely limited in providing useful information for high-level reactors. The principal problems connected with production and power reactors stem from the very high temperatures at which they operate and the high neutron fluxes present in them. However, if people working with low-level reactors keep in touch with those concerned with the development of new types of reactors, they may be able to make useful contributions to certain rather fundamental reactor development problems which are essentially of an unclassified nature and can be investigated at an unclassified university laboratory.

Low-level reactors have already found considerable use in research, here and in Britain, Canada and France. Such reactors make available a valuable neutron source (a flux of 3×10^{11} n/cm^2/sec at Los Alamos, for example) for nuclear physics work, studies on the effects of radiation on various materials, medical research using short-lived activities, etc.

In industry, it has been pointed out that petroleum and chemical companies have numerous applications for the neutron and gamma fluxes from water boilers.

For educational use, low-level reactors would permit students to get a *first-hand, unclassified picture* of what makes reactors tick. But they would

have limited use for training nuclear engineers in the practical aspects of power reactor technology.

With the numerous possible applications of low-level reactors, it has been very surprising that more interest has not been expressed in them, particularly by universities. According to the AEC, North Carolina State College was the only institution to submit a practical proposal.

Similar lack of interest seems to have been shown in the case of the "improved" research reactor designed by North American Aviation, Inc., specifically for research and training, presumably by non-AEC groups. This reactor would provide a higher neutron flux than the water boiler and would cost about four times as much ($1–2 million). However, although various groups are interested in such a reactor, none have presented any formal proposals.

Thus, if it weren't for the initiative of North Carolina State College, it might have been some time before such a project came into being. *It is now hoped that other schools will see the advantages of such research tools.* It is indicated that the AEC would seriously consider proposals similar to that made by North Carolina.

With regard to high-level reactors for the production of power, industry has similarly lagged in presenting any positive proposals regarding the building of reactors by industry. Of course many more problems, such as finances, hazards and security, are introduced. But the AEC has also not shown any initiative along these lines.

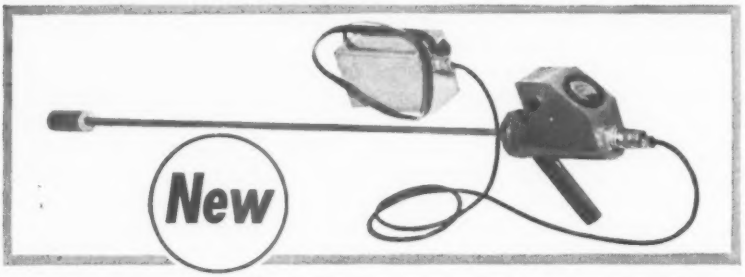
Within the past six months, however, Charles A. Thomas of Monsanto Chemical Company has presented a proposal to the AEC (see NU, Aug. '50, p. 72) which is now being given serious thought. Thomas wants AEC to permit Monsanto (in conjunction with several other companies) to build a power reactor, using fuel leased from the AEC. This would be a multiple-purpose pile, producing plutonium to be sold to the government and by-product heat to be used by industry.

The AEC states that the most serious drawback to this or any similar proposal is the extremely limited number of capable reactor engineers in this country. With the high-priority military work being carried out, the AEC would be quite reluctant to approve any plan which might divert its manpower.

It should be pointed out that recent AEC thinking has been towards greater industrial participation. One top AEC official said last month that the "fastest progress would be made if we could move toward the design and construction of reactors on a competitive bid, fixed price basis, or by otherwise utilizing a profit-making incentive. . . . This will not be easy but I believe that ultimately it can be done if we in Washington have both the will and the ingenuity."

To achieve still greater non-AEC participation in this field, *two things are essential:* (1) AEC must pursue a positive program of informing non-AEC groups of what goes on behind the curtain (the subject of a future editorial), and (2) non-AEC groups must press for such an AEC policy and take a positive stand on their interests. —*Jerome D. Luntz*

WORK PROTECTED with General Electric's New Long-Probe Gamma Survey Meter!



- Measures 0.3 R per hr. to 3000 R per hr.
- Locates beams in particle accelerators
- With light-weight 6′ probe, operator can work from behind protective lead sheath

5 TIMES THE EFFICIENCY of normal boron counters!

General Electric's new ENRICHED counter

- Measures neutron flux
- Counts neutrons from particle accelerators
- Has many health physics applications

FREE RADIATION HANDBOOK

Ask your G-E salesman for a copy. It lists a complete line of General Electric equipment for radiation laboratories.

WANT MORE INFORMATION?

Write for GEC-732 to Section 687-52, Apparatus Department, General Electric Company, Schenectady, N. Y.

You can put your confidence in—

GENERAL ELECTRIC

687-52

Authorization of the construction of the first privately owned and operated reactor at North Carolina State College is representative of an important trend in this country. The Editors of NUCLEONICS want to congratulate the officials of State College for the initiative and foresight they showed in presenting their proposal, and the Atomic Energy Commission for approving it. We are pleased to present here the first of several articles on this project by Dr. Clifford Beck, the man who was most instrumental in this achievement. Dr. Beck, who was quite active in the Manhattan Project, was also research director of the Gaseous Diffusion Project after the war.
—The Editors

Nuclear Reactor Project at North Carolina State College

By CLIFFORD K. BECK

Department of Physics, North Carolina State College
Raleigh, North Carolina

AFTER MANY MONTHS of negotiations, the U. S. Atomic Energy Commission and the Consolidated University of North Carolina jointly announced on October 29, 1950, that the first non-AEC constructed and operated nuclear reactor in the United States would be erected on the North Carolina State College campus at Raleigh, N. C. This announcement came 16 months after the first proposal for construction of a reactor at State College was made.*

The reactor project at State College is an outgrowth of and is intimately connected with the college's program of instruction and training in nuclear engineering. A four-year undergraduate curriculum and a graduate program leading to the degree of Master of Science in Nuclear Engineering has been set up by the college.†‡ Sixty students, including 28 assigned U. S. Air Force officers, are enrolled in these curricula. The idea that a nuclear reactor might be built on a college campus under the direct control of the college, and the circumstances which led to AEC's authorization of such a project are inextricably related to the factors which led to establishment of the training program in nuclear engineering at State College.

Chronological Developments

When the reactor and training proposals were first put forth in July, 1949, enthusiastic support was immediately forthcoming. In the period immediately following, major effort was

* Clifford K. Beck, "Proposal of a Nuclear Reactor at North Carolina State College," *N. C. State College Bulletin*, July 5, 1949 (revised July 5, 1950).

† Clifford Beck, "A Curriculum in Nuclear Engineering at North Carolina State College," *N. C. State College Bulletin*, March 25, 1950.

‡ Clifford Beck, "Undergraduate Nuclear Engineering Curriculum at North Carolina State College," NUCLEONICS, January, 1951.

BACKGROUND OF NORTH CAROLINA

At North Carolina State College. *North Carolina State College is the technical (agriculture, architecture, engineering, and textile) branch of the Consolidated University of North Carolina. An alert and aggressive leadership at the college has responded to steadily increasing demands in the Southeast for graduates with higher levels of technical training by offering expanding training opportunities at advanced levels and by offering strong encouragement to research programs. Several engineering departments have recently instituted doctorate programs, and staff research programs are strongly encouraged.*

The dual responsibility of the college has been recognized and accepted: on the one hand, of producing graduates with thorough technical training in fields of major vocational opportunity, and, on the other hand, of leading out in the Southeast on research programs directed to inauguration of new, and improvement of old, industrial processes.

It was clearly realized in 1949 that these expanding activities in the engineering departments of the college would demand the support of a strong staff in physics. With the retirement of the chairman of the physics department, new leadership in this department was sought and plans were laid for a major expansion in advanced instruction and research in physics. Since several departments of the college were carrying out research involving radioactive materials, it was decided that some emphasis on related subjects in the renovated physics department was desirable.

In the Atomic Energy Program. *There were at least three significant factors within the atomic energy program which were strongly favorable to the proposal of a nuclear reactor program on a college campus.*

1. *It was increasingly clear that nuclear processes and accompanying technology could not be confined to limited areas of military applications but were destined to exert a significant effect on virtually all branches of science and engineering. A growing need was being felt that wider participation in the atomic energy program by industry and established educational institutions was necessary if the United States was to maintain her preeminence in atomic weapons and, at the same time, develop the peacetime potentials of nuclear processes. Hence, through research contracts and personnel exchange, "outside" institutions and organization were*

concentrated on development of the training program.

In April, 1950, a series of conferences and preliminary studies led to a formal proposal by State College to the AEC that construction of the reactor at Raleigh be permitted and the requisite fissionable fuel be loaned to the college. In response, the Commission suggested that detailed design of a suitable reactor adaptable to its intended instructional and research use on a college campus be worked out. A contract between the Commission and State College was drawn up which provided the college access to such classified information as was needed to complete the design studies.

A report* was presented to the AEC in August, 1950, containing a complete description of all the major features of the reactor and as much of the details as could be worked out in advance of

* Program Administration and Installation Design of the Nuclear Reactor Project at N. C. State College, by Clifford Beck, A. C. Menius, Jr., A. W. Waltner, et. al., July 5, 1950.

STATE COLLEGE PROPOSAL

already being encouraged to engage in research relating to atomic and nuclear processes.

2. *As a result of the information dissemination program that was pursued, the fundamental principles and many of the details relating to "water-boiler" nuclear reactors and nuclear engineering in general had become available to the public. This material, however, was rather widely scattered and disorganized, though a few coherent topical collections were appearing.*

3. *An increasing demand was clearly in evidence, both inside and outside of the AEC, for educational and training opportunities in nuclear technology and engineering. Establishment of AEC fellowships and scholarships and of training courses and even curricula (e.g., at Oak Ridge National Laboratory) within AEC facilities were evidence of an "inside" need for more men, adequately trained. Vigorous competition for the fellowships, establishment of such groups as the Oak Ridge Institute of Nuclear Studies by Southern universities and a general increase of interest in nuclear courses in all universities were evidence of wide "outside" demand for such training.*

The educational efforts and training programs within AEC auspices were necessary expedients designed to meet the exigencies of an unusual situation. In the early days of the atomic energy program, it was necessary that training programs directed specifically to the needs of the project be set up within the atomic energy program. Some of these training programs will need to be continued, for new employees of any large organization must be given specialized instructions relating to the particular "company" situation, and, also, in cases where classified matter is involved, the educational efforts cannot be relegated to outside institutions. However, as established educational institutions began to prepare for expanding programs directed to training in the fundamentals of nuclear technology, it was recognized that facilities such as nuclear reactors and other major apparatus would need to be made accessible to these institutions.

A number of factors, therefore, within the atomic energy program were favorable to the "outside" development of educational and research facilities in nuclear technology when, in 1949, proposals for the State College program were made.

detailed experimental and engineering studies. It was requested that the Commission, on the basis of the over-all features of the reactor and the underlying features of the project, make a definite commitment regarding its eventual position on the matter.

On October 12, 1950, the AEC informed State College that its proposal was approved, and, upon completion of a suitably designed reactor, the requisite nuclear fuel would be loaned to the college.

At this writing, many decisions must still be made. Details of design, security, classification, handling of isotopes by participating research groups, etc., still have to be worked out.

Philosophy of Project

Fundamentally, the nuclear reactor was sought for the State College campus as the center around which instruction, training and research programs in nuclear technology and engineering could be built. All features of the re-

actor program are related to this basic intent. The reactor is considered a tool in the same sense as is a cyclotron, which is used by the school possessing it as an integral part of its total laboratory facilities. As far as possible, recognizing of course certain complicating factors, it is intended that our reactor will be similarly used.

A number of important features of the State College proposal derive from this concept.

1. It is intended that the reactor be built and subsequently operated completely under the control and direction of North Carolina State College. No criticism whatever of the AEC is intended or implied in this. On the contrary, definite arrangements will be made for maintaining close contact with the AEC, for the advantages of such liaison are obvious. However, it is obvious that as close an approach as possible to the customary and traditional manner of integrating such projects into the total college or university program would, in the present case, greatly facilitate achievement of the research and instruction goals of this program.

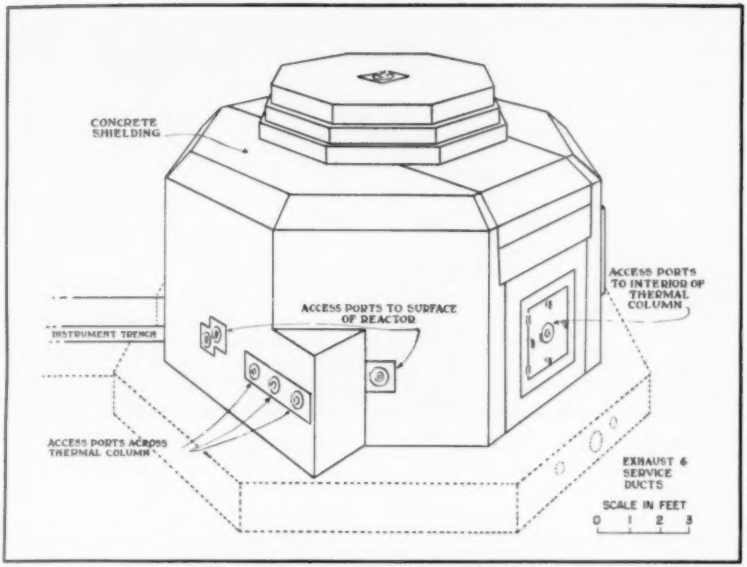
2. To achieve this independence as far as possible, it was decided at the onset that the finances for the nuclear reactor would be supplied by college funds. This feature of the program is one of the most significant. Without the complication of financial subsidy from the AEC, attention could then be focussed on the other items requiring negotiation and settlement.

3. The "water-boiler" type of reactor sought is one of the simplest and most fool-proof, and is of very modest size, although the variety of apparatus involved and the adaptability and flexibility of the unit makes this type exceptionally well-suited to its intended instructional and research uses. By seeking a well-proven type of reactor, of modest size, having all its major features already declassified, the concern of the AEC over potential hazards and possible inadvertent release of classified data has been kept to a minimum.

4. It was decided quite early that an adequate staff, thoroughly competent to man the reactor project, would be secured by the college. This was important, of course, from the standpoint of the quality of the physics department. Incidental to this, the presence in the college of men experienced with chain-reacting processes increased the confidence of the AEC in State College's ability to manage effectively the program it had proposed to undertake. In addition to the presence in the engineering school of a number of well-trained engineers, three staff members of the physics department have had extensive research experience with systems of chain-reacting assemblies of uranium.

Most of the men in the physics department involved in work on the reactor and a number from other departments of the college will maintain Q-clearance status with the Commission and will receive up-to-date information on the boundary between declassifiable information and that which must remain guarded. With these men as the core of an extensive team of scientists and engineers, there is ample knowledge and experience available at State College for intelligent execution of the proposed program.

The final decisions on security requirements and classification status of the reactor have not been made. Security-wise, the chief problem is that of safeguarding the enriched uranium fuel contained in the reactor. The reactor is being designed so that access to the fuel for purposes of theft would be exceedingly difficult. After initial operation, the residual activity of the fuel will provide a further safeguard. The completed reactor design will also


CONCRETE SHIELDING
ACCESS PORTS TO INTERIOR OF THERMAL COLUMN
ACCESS PORTS TO SURFACE OF REACTOR
INSTRUMENT TRENCH
ACCESS PORTS ACROSS THERMAL COLUMN
EXHAUST & SERVICE DUCTS
SCALE IN FEET
0 1 2 3

Schematic view of completed reactor assembly

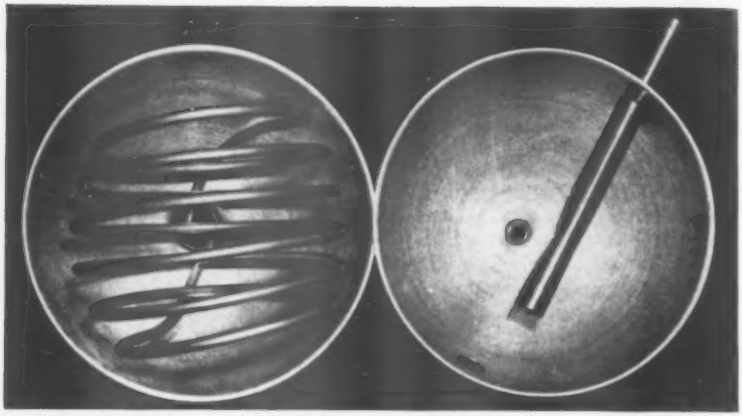
contain several distinct features intended as a deterrent to any possible sabotage attempt. Thus, the fuel security problem should not be difficult to solve.

The classification problems are somewhat more complex. It now appears that the entire facility and all its parts will fall into the completely unclassified category. It may eventually be decided, however, that a few details of the internal mechanism of the reactor cannot be released. Should this turn out to be the case, no major problems will result beyond that of added inconvenience during construction of the unit. Whether certain details of the reactor are classified or not, it is intended that its operation will proceed on an unclassified basis, since only the operators, already cleared for classified data, need to know the structural details.

The research groups who use the reactor, e.g., those who use the emergent beams, or those who introduce samples into the exposure ports for irradiation, will do so on an unclassified basis. It is not intended that special clearance of any kind will be necessary for the members of these groups.

The research program involving the reactor will normally be devoted to unclassified problems in any field of scientific or engineering interest. It is expected that research teams from a number of institutions in the area around Raleigh, as well as from all branches of the university, will make use of the reactor facility. Problems of a classified nature will not normally be undertaken, for this would cause inconvenience to the students and staff in the type of facility visualized.

In the course of unclassified investigations, however, should classified data, or information of uncertain classification, be encountered, it will be de-



Stainless-steel sphere, 1 ft in diameter, holds enriched uranium fuel solution in Los Alamos water boiler. Cooling water is circulated through tubes at left; tube at right, when welded in place, is used to introduce samples into flux. Core of reactor at North Carolina State College will be a 1-ft diameter cylinder

cleared classified, and thereafter it will be handled through prescribed channels.

Description of Reactor

The State College nuclear reactor is of the uranium "water-boiler" type, designed for a maximum power output of 10 kw. The water-boiler type reactor was first designed by scientists at the Los Alamos Scientific Laboratory, where such a reactor has been in operation since 1944.

A water-boiler facility consists essentially of three major parts: (1) the reactor itself, which is a closed metal vessel containing on the order of one kilogram of highly enriched uranium fuel dissolved in a few gallons of water; (2) auxiliary systems, such as cooling coils, control rods, radiation detectors, gas disposal apparatus, "thermalizing column," neutron reflector, etc.; and (3) shielding around the reactor, consisting largely of lead layers and several feet of concrete. Channels and openings in the shielding permit escape of useful radiation beams or insertion of samples into the reactor for irradiation.

The water-boiler type of reactor was chosen for a number of reasons: (1) over several years of operation, the reactor at Los Alamos has been found adaptable, useful, and safe to operate; (2) practically all the features and components of this type of unit are in unclassified or declassifiable categories; (3) a water boiler of the chosen type has inherent characteristics which make it absolutely free of any nuclear explosion hazard, even though all normal and emergency control devices should fail; (4) such a reactor is small and compact, and provides relatively intense beams of radiation; and (5) the structural features of this type of reactor and its auxiliary apparatus are simpler than those of many other reactors.

The State College reactor will consist of a 12-inch cylindrical fuel chamber of stainless steel, containing approximately one kilogram of uranium in the form of uranyl sulfate dissolved in water. Attached to or imbedded in the fuel cylinder will be cooling coils, control rods, sampling lines, etc. The cylinder and its attached apparatus

will be located in a cavity near the center of enclosing layers of graphite (for neutron reflection), lead and concrete (for radiation shielding). The concrete shielding structure, from four to six feet thick, will be octagonal in horizontal cross section. The over-all assembly will be approximately seventeen feet across and ten feet high (see drawing on p. 9). Four-inch circular channels will extend horizontally and radially from the fuel cylinder through the concrete to the center of each octagonal face of the shield. These port-holes will permit access to the reactor radiation for experimental purposes.

The control console for the reactor will be located in an adjacent room. An instrument trench will extend from the measuring and controlling devices inside the reactor shielding downward to a point underneath the assembly and then under the floor to the console.

When a water boiler is in operation, three resulting products are handled:

1. Heat—in the present reactor this will be removed by circulation of water through coils in the fuel solution.

2. Radiation—this in the present case is the desired product. It will be used for irradiation of samples inside the shielding, or as beams emerging from the port-holes. The unused part of the radiation will be absorbed in the shielding. Final calculations are not complete, but present indications are that an internal thermal neutron flux of $> 10^{12}$ n/cm²/sec will be achieved.

3. "Off-gases"—these are of two types: (a) Gaseous fission products, resulting from the utilization of the uranium fuel. These are extremely small in volume, but are highly radioactive in nature. (b) The gaseous decomposition products resulting from the radiation-decomposition of the liquid in the fuel. These are mostly hydrogen and oxygen, which are not appreciably radioactive, themselves, but are contaminated with the highly radioactive gaseous fission products. The volume of these decomposition gases may be relatively large.

A gas disposal unit, therefore, is needed. The one now being designed involves (1) recombination of the hydrogen and oxygen to reduce the volume and remove the gas explosion hazard, (2) storage of residue gases in a holding tank until the radioactivity has decayed to tolerable limits, and (3) disposal by blowers through a 120-ft stack to the atmosphere.

Hazards

Any modern physics laboratory possesses instruments and machines potentially hazardous to the physical well-being of the laboratory staff: high voltages, compressed gases, X-ray machines, etc. To these, which have become somewhat familiar, must now be added radioactivity and reactor radiations. The latter, however, like all other hazards, can be avoided by adequate safety training, insistence on approved technique, and when possible, built-in, fool-proof automatic safety features in the equipment itself.

The chief potential hazards of the State College reactor fall into a few distinct categories. When the reactor is in operation, radiation streams out in all directions. Most of the radiation, of course, will be absorbed in the concrete shielding, but beams of high intensity will escape into the reactor room through any beam ports left open, either inadvertently or intentionally. This hazard is one that must be met through rigid control of operating procedures, physical barriers adjacent to beam paths, and enforcement of safety regulations. The reactor operator will be located outside the reactor room and, in general, an experimenter will rarely be in the reactor room when the reactor is in operation.

A second normal hazard involves handling and disposal of the gases

evolved during operation of the reactor. Two hazards really are involved here: the first, that of explosion due to the presence of hydrogen and oxygen in the gases discharged from the reactor; the second, the radioactivity of the product gases. The explosion hazard is considered to be very small. The total volume of oxygen and hydrogen is small; it is contained within the stainless steel fuel-gas systems located within the concrete shielding; the chance of igniting the gas or initiating an explosion is quite remote. If an explosion should occur, the tubing walls of the gas disposal system might possibly be ruptured, thus releasing radioactive gases into the room, but direct harm to personnel from the combustion itself could hardly occur. The gas disposal system now being devised for the reactor is expected to reduce the gas explosion hazard essentially to zero.

The highly radioactive residual permanent gases from the reactor, after removal of the recombined hydrogen and oxygen, will pass along a tortuous path through a holding system of large volume, where the radioactivity will decay to tolerable levels, and then the gases will be blown into the atmosphere.

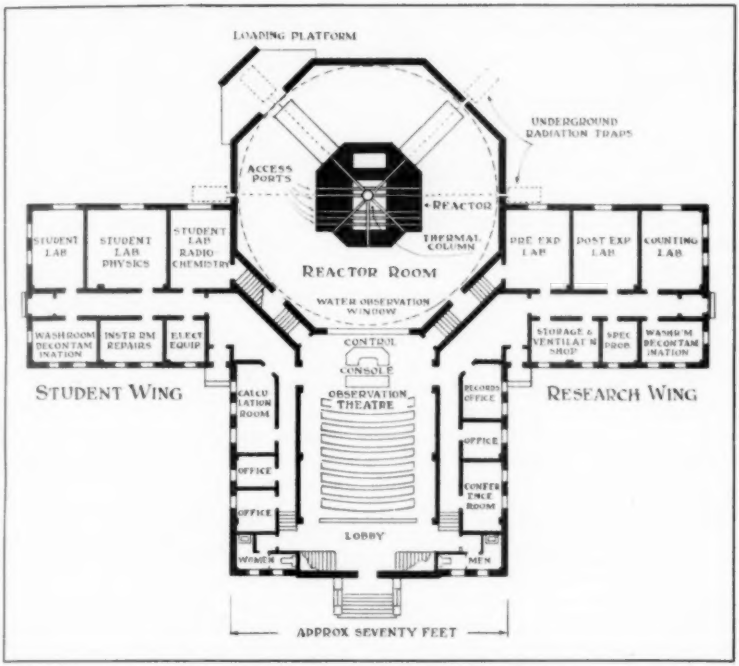
No misoperation of the reactor or failure of safety devices can cause a major catastrophe. It would be virtually impossible even by deliberate effort to cause a nuclear explosion in this type of reactor. The major possible catastrophic hazard is that which could result from sabotage. By sabotage with non-nuclear explosion, it is conceivable that the fuel cylinder of the reactor might be blown up, with the dispersal of the fuel over the surrounding area as a liquid or into the atmosphere as a vapor. To do this, the explosive material would have to be placed inside the massive shielding in the vicinity of the fuel cylinder and set off there. To spread the fuel over the surrounding area, the explosive would have to be sufficiently powerful to demolish the concrete shielding structure. A sabotage assignment of this sort would be very difficult, but it could conceivably be accomplished. Numerous devices, locks, and interlocks are included in the design of the reactor and building to minimize this possibility.

Associated Reactor Laboratories

It was originally intended that the reactor would be located in an existing building on the campus.* Later, it was decided that a special building to house the reactor and the laboratories associated therewith should be constructed. The Burlington Mills Foundation, one of the widely known textile organizations in North Carolina, donated $200,000 for this purpose. The figure on p. 13 shows a schematic diagram of the functional components of the building. Architectural design studies, now under way, will result in floor plans considerably altered from those in the sketch, but the finished building will consist of the four essential components shown:

1. *Reactor room.* The octagonally shaped reactor assembly will be located in the center of a "reactor room," with at least 30 feet of clear space between any side of the reactor and the nearest wall of the building. The floor level in the reactor room (and the bottom of the reactor assembly) will be 6 feet below ground level. Horizontal radiation beams which emerge from the reactor will pass through narrow openings in the building walls to underground radiation traps buried outside the building. Above the high ceiling (35 feet) of the room, there will be provided space for blowers, filters, ventilation equipment and other apparatus. The wall of the reactor room will be of 16-inch masonry and steel (for supporting a 10-ton crane), except on one side

* See ref. on p. 5, col. 1.



Schematic floor plan of Raleigh reactor building

adjacent to the control observation room where a large 16-inch thick water observation window will be located. Numerous crash-doors will provide emergency exits from the reactor room. Blowers will draw in air through ventilators in the walls, filter it, and discharge it, via the stack, to the atmosphere. The ventilators will be arranged for outside closure, if necessary, so that the entire reactor room can be sealed up from the outside to prevent other than minor escape of gases from inside in case excessive gas contamination should occur in the room.

2. *Research Wing.* Adjacent to one side of the reactor room, a laboratory wing devoted to pre- and post-handling of exposure samples involved in research projects will be built. The laboratories in this wing will have facilities for radiochemical work and radioactivity measurements, in addition to the usual research facilities. Air conditioning, and exhaust ventilation of these laboratories through ducts leading to the building stack, will be provided. Facilities for checking and eliminating radioactive contamination of hands or clothing, and for lockers, clothes-changing, scrubbing, etc., will be arranged near the normally used entrance to this wing.

3. *Student wing.* A second laboratory wing adjacent to another side of the reactor room (opposite the research wing) will be equipped for instruction and training of students in a wide range of nuclear techniques. The wash room, ventilation, and laboratory facilities of

this wing will be similar to those in the research wing. Activities of much lower level will normally be used in the student wing.

4. *Control-observation-administrative area.* An area, essentially a third wing adjacent to the reactor room, will house the control console, the calculations, records, operations offices, a conference room, storage rooms (for uncontaminated supplies and equipment), an observation room, and offices for the reactor staff. No radioactive materials whatever will be permitted in this area. Through the large water window, (i.e., plate glass sides with a layer of water between), which protects observers from stray radiation from the reactor room, the operation and usage of the reactor and its associated equipment may be observed. The observation room will accommodate 75 persons.

Costs, Time Schedule

It was estimated in March, 1950, that the reactor could be built in an existing building and brought to full operating condition for $150,000, exclusive of the uranium fuel (to be loaned by the Commission) and the exhaust stack (existing). The breakdown was:

1. Alteration to building, five-ton crane, excavation for reactor foundation.	$ 30,000
2. Reactor construction: building of forms, pouring concrete, including foundation and forms for holes and channels.	30,000
3. Fuel solution system, control rods, reflector and thermal column.	20,000
4. Instrumentation, control panel and accessories.	30,000
5. Contingencies: consultants, auxiliary apparatus, etc.	40,000
	$150,000

The cost of the building (diagrammed on p. 13) was estimated in March at $225,000. It has a volume of approximately 300,000 cubic feet; a floor area of about 12,000 square feet.

Revised estimates have not been made since the onset of widely fluctuating prices in mid-summer. Also, the final designs of reactor and building have not been made. Hence, an exact estimate of cost is not available. It is believed, however, that the entire facility can be completed for $350,000 or less.

Construction of the reactor building is expected to begin early in 1951. The building will be completed before the end of 1951.

A scale model of the reactor has been completed. A second, larger, model was scheduled to be started on December 1. In this one, plaster-of-paris will be used as a substitute for the concrete, and procedural steps for constructing the concrete bulk for the actual reactor will be decided upon. Meanwhile, the various component parts of the reactor assembly will be assigned to different groups in the engineering school for study, construction of models and, finally, construction of the finished part. When the reactor building is sufficiently complete for the concrete bulk of the reactor to be poured, it is expected that most of the component parts of the reactor and its auxiliary systems will already be finished. An optimistic estimate places the expected completion date of the entire facility at January 1, 1952.

* * *

Editors' Note: *A description of the undergraduate nuclear engineering curriculum at North Carolina State College will appear in the January issue. Arrangements are also being made to publish further details of the development of the State College reactor project in later issues of NUCLEONICS.*

PRESENT STATE OF NUCLEAR PHYSICS

This is a report on the recent International Conference on Nuclear Physics held in England. The meetings underscored the fact that our theoreticians simply do not have enough material at the present time to establish the pattern of the nucleus and await accumulation of many more experimental results before they can comprehend it completely

By URNER LIDDEL

Office of Naval Research, Washington, D. C.

THE LATEST in the annual series of international conferences on nuclear physics was held on September 7–13, 1950, in Oxford, England, under the auspices of the Ministry of Supply's Atomic Energy Research Establishment (AERE), Harwell. The conference was organized by their staff, and British hospitality was displayed to the fullest extent.

While no momentous announcements were made at the conference, the meeting was an excellent report on the present state of nuclear physics It is hoped that the many interesting papers presented (not all of which could be commented on below because of the limitations of this report) will be recorded in the literature in the near future.

The conference was divided into discussions of particle accelerators, experimental high-energy physics, theoretical interpretation of results, and pile physics.

Prof. L. W. Alvarez (California) initiated the conference with a discussion of the research program at Berkeley. He announced that sextupally ionized carbon was now being used as a bombarding particle for production of transuranic elements. This will permit the formation of heavier elements than californium-244.

Work on the bevatron is progressing but no completion date can be estimated at the present time. Barkas and his group are attempting to get the mass ratio of protons to mesons by clever use of the cyclotron magnetic field which permits the two particles to enter the same photographic plate with known different energies.

Panofsky is examining the scattering of π^--mesons by protons which yields neutrons and gamma rays. The gamma rays are examined by pair production.

Mather has developed an interesting method for measuring the energy of the cyclotron beam by use of Cerenkov radiation. Using a lucite prism, he is able to measure the energy with an accuracy of 1.5 Mev (rms) at 350 Mev. This appears to be the best method yet presented for measurement of cyclotron energies.

Powell's group is using a cloud chamber to study electrons by pair production.

Recently, proton-proton scattering measurements have shown that the cross section is almost constant from 150 to 350 Mev and that the angular distribution of the protons is isotropic in the center of mass system. This means that the particles behave like classical billiard balls in collision. From a study of the decay curves of π-

and μ-mesons, the best values for their mean lives are 2.65×10^{-8} and 2.09×10^{-6} sec, respectively.

Prof. P. G. Kruger (Illinois) described the large betatron recently built by Kerst at the University of Illinois. The present output of the betatron is 360 roentgens per minute at one meter measured by a Victoreen chamber behind $\frac{1}{8}$ inch of lead. The repetition rate of the betatron is six pulses per second. Thus, this betatron has the highest output of any high-energy X-ray machine. The gamma-ray energy was measured by means of a lead calorimeter which provides a classical method of measurement of energy.

Dr. G. B. Collins (Brookhaven) described the present state of the Brookhaven National Laboratory bevatron. The magnet and coils are completed, and better than 80% of the mechanical work is done.

Prof. E. T. Booth (Columbia) described the large cyclotron at Irvington-on-Hudson, New York. This instrument now produces the highest-energy protons of any available machine, viz., 390 Mev. A beam of π^--mesons from the cyclotron passes through the shielding to an external experimental area. Present methods of investigation utilize photographic plates and cloud chambers with magnetic fields. One cloud-chamber photograph was shown which contained eight parallel π-meson tracks with no other tracks evident. This shows a high degree of cleverness in experimental technique in the complete separation of extraneous particles.

Dr. Urner Liddel (Office of Naval Research) read a paper describing in some detail the synchrotron built by Getting at the Massachusetts Institute of Technology. The energy of the gamma rays produced is nearly 350 Mev. Studies on π-mesons are presently underway. Preliminary data give a value of $1.65 \pm 0.33 \times 10^{-8}$ sec for the mean lifetime for π-μ decay. The synchrotron could be used as a continuous source of radiation in the soft X-ray region. Some of these characteristics were given.

Prof. J. H. Williams (Minnesota) described his plans for the construction of a 66-Mev linear accelerator. It will be similar to the Berkeley machine, except that three acceleration tanks will be used (100 feet total length), and it will be driven by a master oscillator power amplifier system with resnatrons in the final stage.

Mr. R. B. Shersby-Harvie (AERE) described a unique linear accelerator (dielectric loaded wave guide). TiO_2 disks are used for loading. The experimental model is 1 meter long. By grading the dielectric, it is hoped very-high-energy (1 Bev) accelerators might be built.

Mr. M. Snowden (AERE) reported some measurements of the beam of the Harwell 110-inch cyclotron. An external proton beam has been obtained by scattering with a thin uranium target into an emergent channel. The external beam was $\sim 3 \times 10^{-10}$ amp.

Dr. N. Bradbury (Los Alamos) described the present status of the electrostatic generator being built by McKibben. The design voltage for this machine is approximately 12 Mev.

Prof. B. J. Moyer (California) described the research underway at Berkeley on neutral mesons. These mesons have now been produced in three separate ways: protons on nucleons, X-rays on nucleons, and π^--mesons on protons. He presented some new work by Panofsky on the capture of π^--mesons in hydrogen and deuterium. These captures lead to six possible reactions:

1. $\pi^- + p \rightarrow n + \gamma$
2. $\pi^- + p \rightarrow n + 2\gamma$
3. $\pi^- + p \rightarrow n + \pi^\circ$
4. $\pi^\circ \rightarrow 2\gamma$
5. $\pi^- + d \rightarrow 2n$
6. $\pi^- + d \rightarrow 2n + \gamma$

The ratio of the probability for reaction *3* to reaction *1* appears to be 0.94 ± 0.2. There is no evidence for reaction *2* oc-

curring. The ratio of reaction *5* to reaction *6* is approximately 2. Panofsky has made an independent measurement of the mass of the π^--mesons by means of reaction *1*. The value for this mass is 271.4 ± 2.5 em (electron masses). On the basis of this measurement, the mass difference between the π^--mesons and the π^0-mesons is 10.6 ± 2 em, which leads to a value for the mass of the neutral mesons of 261 ± 4 em.

Dr. C. J. Bakker (Phillips Eindhoven) discussed some work which he did at Berkeley with Segrè on the stopping power of various elements for 300-Mev protons.

Prof. B. D. McDaniel (Cornell) described their synchrotron and the recent modifications which changed the repetition rate from 60 cycles to 30 cycles. The measured output is 8000 roentgens per hour at 1 meter behind ⅛ inch of lead.

Prof. E. T. Booth (Columbia) described an experiment in which he measured the scattering of π^--mesons. G5 photographic plates with 400-micron emulsion were placed in three positions at an angle of 8° with the incoming π^--meson beam (a) with no shielding, (b) behind 2 cm of copper and (c) behind 0.63 cm of copper. An analysis of the photographic plates showed that some mesons stopped, some mesons produced stars, and some mesons scattered at angles greater than 30°. Analysis of the third stack of plates showed that 60% of the meson tracks were π^--mesons and the remainder were μ-mesons.

Prof. A. Roberts (Rochester) discussed the work of Bradt and Peters on heavy particles in cosmic radiation. Stacks of plates, alternately sensitive and insensitive, were flown at an altitude corresponding to 20 gm per cm². Analysis of the plates showed no lithium, beryllium, or boron nuclei as primary particles in cosmic radiation. This evidence is interpreted as opposing the galactic origin of cosmic radiation. It is believed that the nuclei of the lithium, beryllium, and boron atoms which are found at lower altitudes are produced by the bombardment of other nuclei by protons. Roberts also reported on the Rochester work on proton-proton scattering both in the low-energy range with the small cyclotron and in the 250-Mev range with the large cyclotron. The results confirm those reported by Berkeley and by Harvard.

Prof. N. F. Ramsey (Harvard) discussed some proton-proton scattering measurements by means of scintillation counters. He also mentioned a study made at Harvard of the energy distribution of neutrons from 110-Mev protons. For beryllium, the peak of neutron production is at 95 Mev for 110-Mev protons.

Prof. P. G. Kruger (Illinois) reported on the production of photo mesons with the Illinois betatron and, in particular,

Meson Production by University of Illinois Betatron

X-ray Energy	232 *Mev*		299 *Mev*		340 *Mev*	
Meson Energy (Mev)	*Number of π*	*Ratio π^-/π^+*	*Number of π*	*Ratio π^-/π^+*	*Number of π*	*Ratio π^-/π^+*
30–55	101	1.0	613	2.3	416	3.1
45–70	101	1.5	324	1.6	133	1.1
65–90	...	...	356	1.3	146	1.3
80–100	...	...	~ 500	1.5	200	1.0

the ratio of the formation of π^- and π^+ mesons (see tabulation on the preceding page). The cross section for pair production in foils by electrons at 65 Mev is approximately equal to 3 barns.

Prof. R. B. Brode (California) described recent measurements on the mass spectrum of cosmic-ray particles at sea level. He found evidence only for particles in the 300 and 2,000 mass range, i.e., no evidence for any particles of intermediate mass of approximately 1,000.

Prof. M. G. E. Cosyns (Brussels) discussed his work on the angular correlation of high-energy cosmic-ray showers formed in electron-sensitive emulsions exposed at an altitude of 2,900 meters. Correlation seems to increase with larger numbers of branches in the showers. The results are not conclusive in deciding between multiple and plural production.

Prof. P. M. S. Blackett (Manchester) discussed the V-particles first reported as heavy mesons by Rochester and Butler in his laboratory in 1947. Blackett said that he and Anderson agreed to call these particles "V-particles" in order not to confuse them with other types of mesons, until more was known about their characteristics. His paper consisted largely of a discussion of Anderson's unpublished results, but Blackett reported that he had found ten additional "V" tracks which aid somewhat in the statistics on these particles. Thus, Anderson has found thirty tracks resulting from the decay of a neutral particle and four tracks resulting from the decay of a charged particle. Blackett has found nine tracks resulting from the decay of neutral particles and one from the decay of charged particles. The best estimate of the rest lifetime of the neutral particle is $3 \pm 2 \times 10^{-10}$ sec. The lifetime of the charged particle is much less than that of the neutral. On the basis of the rather fragmentary statistics there are more neutral than charged particles. Blackett believes that it is not possible for the decay particles to be either electrons or protons, inasmuch as all the interactions correspond to those of π mesons. Thus, the neutral "V" will decay into a positive and negative π meson, while the charged "V" will decay into an appropriately charged π plus a neutral π. Blackett estimates that 10% of the π mesons in cosmic rays arise from V-particle decay. He stated that he would be very surprised if the mass of the V-particle fell outside the range of 700 to 900 em.

Dr. P. H. Fowler (Bristol) reported on his recent cosmic-ray research. Ilford G5 plates with minimum ionization emulsion were flown by balloons to 65,000 feet for a period of 1½ hours. The plates showed 15,000 disintegrations in 100 cc of emulsion. The range of particles was from 300 to 100,000 Mev. Fowler interpreted the data to mean that essentially no alpha particles are emitted in cosmic-ray stars but, rather, that there are large numbers of deuterium and tritium particles. Out of some 1,500 particles, he estimated that 16 were alpha tracks and 500 were deuteron and triton tracks. His analysis of shower data shows the discrepancy that the sum of the energies of all exit particles from stars is less than the energy of the incoming shower particle. This difference may be accounted for if approximately as many neutral mesons are formed as charged particles. It is difficult to understand how the deuterons can be present as such high-energy particles, inasmuch as their binding energy is only 2 Mev.

Mr. D. T. King (Bristol) reported his measurement of the lifetime of the π° meson using bremsstrahlung pairs observed in cosmic ray plates. His calculations gave the value 3×10^{-14} sec. Discussion of the paper showed that the resolution of the method was 1.5×10^{-14} sec, and the audience seemed to

believe that the question of the lower limit on the mean lifetime has not been established.

Dr. T. Pickavance (AERE) discussed research with AERE's 110-inch cyclotron with which neutron-scattering data over the range from 145 to 169 Mev has been obtained. He stated that 171 Mev is the maximum energy of the cyclotron. At 156 Mev, the total cross section for protons was 46.6 mb (millibarns), and for carbon, 330 mb. At 110 Mev, the cross section for hydrogen was 78 ± 13 mb and for carbon was 446 ± 20 mb.

Dr. J. M. Cassells (AERE) discussed the neutron spectra from 171-Mev protons on Cu, Al, and Be.

Dr. E. W. Titterton (AERE) discussed some stars from high-energy neutrons observed on photographic plates. He examined some 5,000 neutron-induced stars and 1,000 proton-induced stars. The cross section for Li^6 production was given as ½ mb and the cross section for the silver bromine complex as 95 mb.

Dr. A. Pais (Princeton) gave an excellent summary of the present state of theoretical knowledge concerning the nucleus. Present experimental data on p-p scattering do not permit discrimination between Yukawa and square-well potentials. An accuracy greater than 10% at 10 Mev is required. In fact, one gathered from his discussion that greater accuracy in experimental results was far more important than extending the energy range of the measurements to higher values (>400 Mev).

Prof. T. Lauritsen (California Institute of Technology) described the electrostatic generators in his laboratory and discussed his recent comprehensive review of energy levels in light nuclei.

Prof. S. Devons (Imperial College) discussed the selection rules for the $F^{19}(p, \alpha)O^{16}$ reaction. This reaction is presumed to proceed as follows:

$F^{19}, p \rightarrow Ne^{20*} \rightarrow$

α + electron-positron pair $\rightarrow O^{16}$

Both of the two lowest levels have zero spin and even parity; hence a gamma transition is not possible.

Prof. W. Bothe (Heidelberg) reported the work on the energy levels of N^{15} from n-p and n-α reactions. The neutrons were observed from RaBe source. The levels ranged from 1.07 to 8.70 Mev. A complicated decay scheme was shown.

Prof. J. Rotblat (St. Bartholomew's Hospital) has studied the energy levels of C^{13} and O^{17} using an 8-Mev deuteron beam. The measurements were made using the photographic-plate technique. He considers that several lines previously attributed to C^{13} were probably due to O^{16} contamination.

Prof. W. Bothe (Heidelberg) showed several pictures of positron scattering by, presumably, electrons in cloud-chamber photographs taken in a magnetic field. The radiation was 600-kev positrons from Cu^{64} magnetically separated to have an energy variation less than 100 kev. A most unusual picture showed three successive scatterings by the same positron particle.

Prof. T. W. Bonner (Rice) discussed the $Be^9(d,n)B^{10}$ reaction. The results indicate that both S- and P-wave neutrons are present above 1-Mev deuteron energies, whereas only S-neutrons are emitted below the threshold (920 kev).

Dr. R. F. Taschek (Los Alamos) discussed the $T^3(p,\gamma)He^4$ reaction. The total cross section for the reaction approaches a maximum at 2-Mev proton energy. He discussed the T-T reaction wherein an alpha particle and 2 neutrons could result with a Q of 11.4 Mev or He^5 plus 1 neutron with a Q of 10.6 Mev. The He^5 would decay to an alpha particle plus a neutron with an energy of approximately 0.8 Mev. Taschek stated that they had no more evidence for the di-neutron. *Dr. J. H. Sanders* (Oxford) stated that they had also found no evidence for the di-neutron at Chalk River.

Mr. B. Flowers (AERE) said that he

believed the $T(p,\gamma)\alpha^*$ reaction does not exist; i.e., there are no excited states of the He^4 nucleus. The discussion by the audience led to the conclusion that this was not necessarily so.

Prof. S. K. Allison (Chicago) has investigated the energy range from 25 to 400 kev. Proton stopping power was measured for Be, Al, Cu, Ag, and Au.

Dr. W. E. Burcham (Cavendish) discussed his work on p-γ coincidences in (d,p) reactions. In particular, he studied the $B^{10}(d,p)B^{11}$ reaction. He used anthracene counters and claimed a resolving time of 15×10^{-9} sec.

Mr. M. J. Poole (AERE) measured the angular distribution of particles from the $T(d,n)\alpha$ reaction in the energy range 125–200 kev. The cross section was determined to be 5 barns at 200 kev. The reaction was determined to be isotropic in the center of mass system.

Dr. D. R. Inglis (Argonne) discussed the interpretation of angular distribution of nuclear reactions by means of the Breit-Wigner formula, in particular, using the $Li^7(p,\alpha)$ α reaction.

Prof. J. H. Williams (Minnesota) reviewed p-p and p-n scattering experiments for energies up to 30 Mev, and discussed the evidence for spherical symmetry (S-wave interaction) of the scattering. On the basis of these results, it appears that the scattering of these particles is charge-independent, and thus a new short range force must be present.

Dr. R. E. Bell (Chalk River) described some experiments using their heavy-water reactor. Using a very-high-resolution gamma-ray spectrometer, he determined the binding energy of the deuteron to be 2.230 ± 0.007 Mev. Bell described Kinsey's work on the spectra of gamma radiation from a large number of elements resulting from neutron capture (in the reactor). Below nitrogen, a single line is observed for the transition to the ground state. For larger atomic numbers, the spectrum becomes more complex; e.g., Al shows about 15 lines, with the ground state transition being the most intense. Heavier elements have more complex spectra with the ground-state transition weakening in intensity. Pb^{207}, however, shows only a single line corresponding to the ground-state transition. The value for Pb^{207} is about 7.3 Mev, and for Pb^{206} about 6.7 Mev. Pb^{208}, on the other hand, has a complex spectrum. The simplest explanation of this would be in terms of magic numbers, since lead has 82 protons. However, Sr with the magic number 50 protons has a complex spectrum. Bell also reported Robson's experiments on neutron decay. Two magnetic-lens spectrographs were used in coincidence, the first, for detection of recoil protons, and the second, having a variable magnetic field, for use as in ordinary beta-ray spectrometers. A Fermi plot of the beta spectrum gave a straight line (down to 300 kev) with very small errors. The extrapolated end point was 782 ± 13 kev (calibrated against Au^{198}).

Prof. N. F. Ramsey (Harvard) reported his experiments in an attempt to determine the dipole moment of the neutron. Since the neutron exhibits a magnetic moment, it could be assumed, therefore, that there was a sizable charge separation, in which event an electrical moment should be detectable. With extremely clever experimental technique, he obtained a sensitivity of 10^{-19} cm. The best measurement for the electrical dipole moment of the neutron was 1.5×10^{-18} cm. However, this value is so close to the limit of sensitivity of the apparatus that Ramsey believes the dipole moment is probably zero.

Dr. L. Kowarski (Paris) reported on measurements of thermal-neutron-capture cross sections by modulation methods in the Chatillon heavy-water reactor. In one measurement, a neutron

(Continued on page 88)

THE SIXTH INTERNATIONAL CONGRESS OF RADIOLOGY . . .

. . . held in London from July 23–29, 1950, brought forth a wealth of information of interest to NUCLEONICS' readers. Three papers and a report on one of the symposia presented at the Congress were published in the October issue of NUCLEONICS.* Another paper and a symposium report appear below.

Comparison of Geiger-Counter and Ion-Chamber Methods of Measuring Gamma Radiation†

Here stated concisely are the basic differences between these two systems of gamma measurement. Response of each to different quantum energies were compared. Results enable counting rates in copper G-M counters to be expressed as dosage rates or vice versa

By W. K. SINCLAIR

Physics Department, Royal Cancer Hospital, London, England

ALTHOUGH ionization chambers and Geiger counters have been used as radiation detectors for many years, no comprehensive account of the fundamental differences between them has appeared. The ionization chamber was originally most suited for the measurement of comparatively high dosage rates, such as those encountered in X-ray work, while the Geiger counter was suitable only for the relative measurement of weak radiation fields.

With the development of d-c amplifier systems of greater sensitivity and the use of scalers in counting work, it now frequently happens that the two devices are used to measure radiation intensities of about the same order of magnitude. In the protection field, in particular, both instruments are used, and the ranges overlap (*1*).

It is possible, therefore, to make a direct comparison of the response of the two systems to different quantum energies. The general basis of this comparison has already been indicated by Mayneord (*2*). What follows is a description of the experimental verification of the relations deduced with a copper counter and an air-wall ionization chamber used to measure a number of gamma-emitting radioisotopes, covering a range of energies.

Theoretical Determination of C/J

When an ionization chamber is placed in a beam of gamma radiation, the ionization current recorded will depend on the size, shape, wall thickness, and wall material of the chamber. A counter placed in that beam will record a counting rate which depends on the same fea-

* The papers appearing in the October NUCLEONICS were: "Advances in Radiobiology between 1937 and 1950" by Antoine Lacassagne (p. 62), "Protection Against Radiation Hazards" by Shields Warren and Austin M. Brues (p. 70), and "The Betatron in Cancer Therapy" by H. E. Johns (p. 76). The Symposium on Radiation Chemistry was reported by F. H. Krenz (p. 67).

† Paper presented at the Sixth International Congress of Radiology, London, July 27, 1950.

TABLE 1
Calculated Values of Counts per Square Centimeter per Roentgen (Copper Counter)

E (Mev)	ϵ	α ($\times 10^{-3}$)	E_f	C/J ($\times 10^{-7}$)
0.1	0.0018	11.3	3060	3.45
0.2	0.0019	5.94	3010	1.79
0.3	0.0022	4.57	2860	1.31
0.5	0.0032	4.00	2740	1.10
0.7	0.0047	4.19	2750	1.15
0.8	0.0055	4.31	2775	1.20
1.0	0.0069	4.31	2860	1.23
1.2	0.0082	4.25	2960	1.26
1.5	0.0100	4.19	3175	1.33
2.0	0.0130	4.07	3475	1.42
2.5	0.0162	4.07	3750	1.52
3.0	0.0198	4.13	3980	1.64

tures. The ionization chamber, however, records energy absorbed from the beam while the counter registers a fraction of the number of quanta passing through it. Both of these quantities depend on the energy of the radiation, and it is possible to deduce a relationship between them.

Consider a parallel beam of gamma rays consisting of N quanta per square centimeter per second when each quantum has energy $h\nu$ in ergs or E in Mev.

The intensity I of the beam in ergs/cm²/sec is

$$I = N h\nu$$
$$= N E \times 1.6 \times 10^{-6}$$

If an air-wall ionization chamber is placed in the beam and conditions are appropriate for the measurement of the dosage-rate in roentgens per second, the ionization J (in r/sec) is given by

$$J = \frac{I}{E_f}$$
$$= \frac{N E \times 1.6 \times 10^{-6}}{E_f}$$

where E_f is the energy flux per roentgen for quanta of energy E.

A counter placed in the beam records a number of counts, which is dependent upon its area. If C is defined as the number of counts per cm² of counter, then

$$C = N \epsilon$$

where ϵ is the intrinsic efficiency defined as the ratio of the number of counts recorded to the number of incident quanta falling on a given area of cathode.

It is well known that the intrinsic efficiency for gamma rays in the region 0.4 to 3.0 Mev is approximately proportional to energy for materials of medium atomic number like copper.

Thus we may write

$$\epsilon = \alpha h\nu$$
$$= \alpha E \times 1.6 \times 10^{-6}$$

Where α is approximately independent of energy,

$$C = N \alpha E \times 1.6 \times 10^{-6}$$
$$= J E_f \alpha$$

or $$C/J = E_f \alpha$$

In Table 1, values of ϵ due to Marty (*3*) are tabulated at different energies. Values of α calculated from them are also given, and it will be seen that while ϵ increases almost proportionally to the energy, α is approximately constant. The values of E_f are due to Mayneord (*4*) and are almost constant over quite a wide energy region.

The values of C/J at first decrease with increasing energy, reaching a minimum at 0.5 Mev after which they increase slowly with increasing energy.

Experimental Determination of C/J

The relation given above could be verified experimentally by counter and ionization-chamber measurements on a group of monochromatic gamma sources. In actual fact, few monochromatic gamma sources covering the desired energy range exist; thus it was necessary to resort to isotopes of rather more complex gamma spectra for which mean quantum energies may be deduced.

A group of sixteen artificial isotopes covering the energy range from 0.08

Mev (Hg^{197}) to 2.07 Mev (Na^{24}) were used. Most of the sources used were directly irradiated in the BEPO (reactor) at Harwell in the solid form and were enclosed in small perspex phials.

Although a knowledge of the activities was not essential, the activities were determined from the ionization measurements, using the latest available disintegration schemes. All the samples except one were within the range 1–30 mc. It is of interest that the measured activities did not differ from the activities calculated from the neutron flux, cross section, and time of irradiation, by more than a factor of 2, except in the case of Cd^{115}. In this case, the measured activity was a factor of 8 smaller than the calculated activity, which may cast some suspicion on the decay scheme (*5*) rather than on the neutron-cross-section determinations.

Equipment and setup. The measurements were made with an ionization chamber and a counter mounted at opposite ends of a 2-meter optical bench. The sources and counter were mounted 50 cm above the bench to reduce scatter.

The ionization equipment comprised a cylindrical graphite chamber, 5 mm in wall thickness, used with an FP54 d-c amplifier system calibrated in roentgens per hour by means of a standard radium source. Most of the measurements were made 10 cm from the chamber.

The counting equipment included a cylindrical copper counter of uniform wall thickness placed with its axis perpendicular to the direction of travel of the quanta. A standard scale-of-100 scaling system was used to record the counting rate, which was corrected for background, resolution time, and decay from the reference time. Most of the sources could be conveniently measured at a distance of 50 cm.

The effective area of the counter was determined by calibrating the counter with a standard Co^{60} source, and the value obtained was confirmed by geometrical calculations based on the axial sensitivity of the counter.

TABLE 2
Experimental Determination of C/J

Isotope	*Mean Quantum Energy*	*Approximate Source Strength (mc)*	C/J ($\times 10^{-7}$)
Hg^{197}	0.08	17.9	4.06
Hg^{203}	0.28	2.73	1.18
I^{131}	0.38	17.05	1.00
Au^{198}	0.41	23.7	0.95
Cd^{115}	0.42	1.34	0.97
Cs^{134}	0.73	6.04	0.97
Ra^{226}	0.84	2.09	1.18
Br^{82}	0.90	0.73	1.10
Sb^{122}	0.57	172.0	1.13
Sb^{124}	1.15	7.4	1.15
Ta^{182}	1.20	1.56	1.19
Co^{60}	1.20	1.12	1.19
Ga^{72}	1.38	19.2	1.21
La^{140}	1.50	18.6	1.24
K^{42}	1.50	31.5	1.20
Na^{24}	2.07	0.42	1.32

In general, the calculation of C/J from the measurements is quite straightforward, but in cases where isotopes of different half-lives and energies are present (for example, Hg^{197} and Hg^{203}, and Sb^{122} and Sb^{124}), the components may be resolved by repeating the measurements at specified intervals. The separation of the two values of C/J is particularly simple if one of the isotopes has a very low mean quantum energy (for example, Hg^{197}).

The mean energy, approximate source activity, and measured values of C/J for the isotopes used are listed in Table 2.

Experimental vs Theoretical Results

The experimental values and the theoretical curve for C/J are shown in Fig. 1 on the next page.

The experimental points lie on a smooth curve which agrees very well with the calculated curve. There are,

however, a few interesting exceptions. Ra^{226} lies a little above the curve, agreeing better with a mean energy of 1.1 Mev than the usual estimated value of 0.84 Mev. The spectrum of Ra^{226} covers a wider range than any of the other isotopes, and a small deviation from the estimated value at the mean energy is therefore not surprising.

Sb^{122} has been placed at two points on the curve, the lower energy 0.57 Mev having been preferred recently (*6*) to the older value 0.80 Mev (*7*). These measurements would seem to support the higher value.

The group of isotopes in the region 0.3–0.6 Mev falls below the theoretical curve by about 5 % and their uniformity seems to suggest a slight error in the theoretical curve. Measurements of the intrinsic efficiency in a copper counter based on absolute determinations of source activity indicate that the values of intrinsic efficieeny used may be slightly in error below 0.5 Mev. The experimental values for C/J are, therefore, probably more reliable than the calculated values in this region.

Nevertheless, the general order of values for C/J as a function of energy seems well established.

Measurement of Radiation Fields

It is well known that in the energy region up to 3 Mev at least, an air-wall chamber may be used to measure dosage rates in roentgens per hour, and it would be very desirable if measurements with a Geiger counter could be expressed in the same way. This form of expression would often be useful in the counting of gamma sources located within the body.

In the protection field, it is more convenient to make portable radiation monitors based on a Geiger counter than on an ionization chamber and sensitive d-c amplifier. The ideal counter for this purpose would be one in which the response would be parallel to that of an air-wall chamber. The C/J curve should therefore be flat, and the counter should have a response which compensates for the variations in the energy flux per roentgen. In these circumstances, the response should be nearly, but not quite, proportional to energy, but it should not, as perhaps might be expected, be independent of energy.

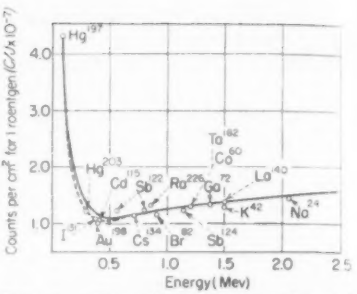


FIG. 1. Theoretical and experimental counts per cm² for 1 r in a copper counter; area determined by calibrating counter with Co^{60} source

Clearly a copper counter only very approximately fulfills the requirements. Values of C/J have, therefore, been calculated for lead and aluminum [using values of ϵ due to Renard (*8*)] and are shown together with copper in Fig. 2.

It is evident that although the lead counter is most suitable over the energy region above 1 Mev it is most unsuit-

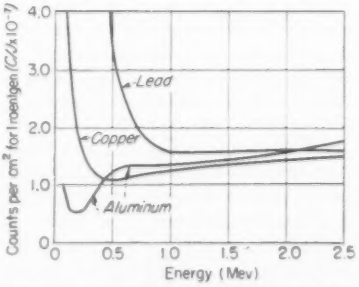


FIG. 2. Theoretical counts per cm² for 1 r in lead, copper, and aluminum counters

able below 1 Mev; the aluminum counter is clearly not as useful as copper for this purpose. Unless a more suitable alloy can be found, copper or medium atomic materials appear to be the most satisfactory.

These considerations are important in the measurement of radiation distribution in a scattering medium. In such a medium, a set of isodose surfaces may be determined with an ionization chamber, while an analogous set of surfaces of constant counting rate may be determined with a counter. Mayneord has suggested the name "equinumeral" for these surfaces, although the term "isocount" has also been used. In general, isodose and equinumeral surfaces do not exactly coincide and in the region below 0.5 Mev large differences may appear between them. Both are derivatives of a more fundamental set in which the energy flow of radiation is constant over the surface.

In actual practical work, the curve of C/J is not as useful as a similar curve of C'/J, where C' is the total counting rate in the counter and not the rate per cm². For the counters used, the curve of C'/J shown in Fig. 3 has approximately the same shape but the values are a factor of about 10 higher.

It is interesting to note that 100 c/sec in this counter corresponds to 10^{-6} r/sec at 1.5 Mev, a very convenient fact in protection work. The calibration in r/sec at 1.5 Mev of a protection meter, incorporating a counter of this type, would be in error by ±15% at most between 0.4 and 3.0 Mev. The slope of this part of the curve may be further reduced by using a somewhat smaller wall-thickness of copper than that used here (0.80 mm).

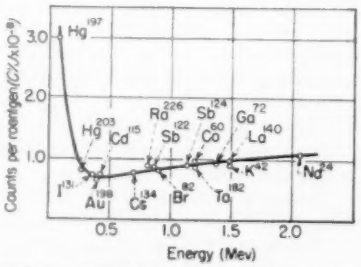


FIG. 3. Counts per roentgen in a copper counter

To see how widely the counting rate varies in counter tubes of the same type, thirteen tubes of the G-M-2 and G-M-4 type* were used to measure the same radiation source. The maximum difference between any two tubes was 7%, provided the end window was covered with a thickness of copper to exclude beta particles. In most cases, the differences were as small as 3%. The ratio of the counting rate with the axis parallel to the beam to that with the axis perpendicular to the beam was, on the average, 0.9.

For medical protection work, the curve of Fig. 3 should be sufficiently accurate for all tubes of this type. Estimates of the dosage rates in r/sec are then immediately available from the counting rate.

Mean Quantum Energy of a Radiation Field

The shape of the C/J curve suggests that a single ionization measurement combined with a single counter measurement may be used to deduce the mean energy of a beam of radiation. Below 1 Mev, a lead counter would be ideal for the purpose, but over most of the gamma-ray region of interest copper is again the most useful material. The slope of the curve is not high enough to enable accurate estimates to be made. However, if the ambiguity in the low-energy region can be resolved, the mean energy may be determined very rapidly, although the error may be as great as 15%. It is nevertheless a very useful method of obtaining mean quantum

* Manufactured by the General Electric Co., Ltd., London, W.C. 2, England.

energies of isotopes with complex spectra, and particularly so in radiological work where a detailed knowledge of the spectral emission is often unnecessary.

* * *

The author wishes to acknowledge his indebtedness to Prof. W. V. Mayneord who suggested this investigation and provided helpful criticism, and to Mr. R. West of the Isotope Division, Atomic Energy Research Establishment, Harwell, for his assistance in obtaining suitable sources.

BIBLIOGRAPHY

1. R. C. Turner, W. K. Sinclair, *Brit. J. Radiology* **21,** 632 (1948)
2. W. V. Mayneord, *Brit. J. Radiology* Supplement No. 2, 174 (1950)
3. N. Marty, *J. phys. radium* **8,** 29 (1947)
4. W. V. Mayneord, *Brit. J. Radiology* Supplement No. 2, 136 (1950)
5. J. L. Lawson, J. M. Cork, *Phys. Rev.* **57,** 982 (1940)
6. W. Rall, R. C. Wilkinson, *Phys. Rev.* **71,** 321 (1947)
7. C. E. Mandeville, H. W. Fulbright, *Phys. Rev.* **64,** 265 (1943)
8. P. Renard, *J. phys. radium* **9,** 212 (1948)

Report of "Symposium on Mode of Action of Ionizing Radiations"*

In this account of the symposium proceedings, a statement of a few of the problems under attack serves as an analysis of the reaction and radiosensitivity of living cells to irradiation of various sorts

By ALMA HOWARD

Senior Cytologist, Medical Research Council, Radiotherapeutic Research Unit Hammersmith Hospital, London, England

WHEN LIVING TISSUES are subjected to ionizing radiations, various biological damage results to which the primary action of the radiation (the formation of ion pairs) is causally linked by a chain of events. The analysis and understanding of this chain was the primary subject for discussion at the Symposium on Mode of Action of Ionizing Radiations.

At the beginning of the chain, some advance can be made through knowledge of the nature of the ions produced (a function of the medium), their linear density (a function of the type of radiation) and their subsequent behavior (a function of the medium in a wider sense, including what other ions and molecules are present). At the end of the chain, the biological result observed will be determined by the complex array of normal life processes, which may be interrupted or destroyed at any point in time or space between the primary ionization and this end result. If these life processes were understood, the mode of action of radiation would be undoubtedly a far simpler problem. As it is, however, the intimate organization, on a molecular level, of even the simplest cell is largely unknown.

Thus, the first difficulty in the explanation of the observed biological action of radiation is the complex and obscure nature of the biological reactor, and as long as the end result is under

* Held at the Sixth International Congress of Radiology, London, July 28, 1950

examination, much of the discussion must concern itself not with how radiations alter biological mechanisms, but with the normal working of these mechanisms.

Clearly, most information will be gained when those biological reactors are chosen about which we already have some knowledge, or which react in a quantitatively definite way to a given radiation stimulus. For this reason, much of the most useful experimental work has been done on simple organisms, such as virus particles, on simple cells, such as yeasts, or on unit stable particles having definite quantitative effects, such as genes. With these materials, there is a better chance of sorting out the effect of the primary ionizations or excitations from the secondary effects which result from a change in some longer chain of events. This distinction is of essential importance if a precise analysis of the mode of action of the radiation is to be achieved, and attempts to draw such an analysis underlie many of the criticisms and discussions which, in the past fifteen years, have surrounded the target theory.

Biologists, observing the varied and sometimes contradictory behavior of living organisms subjected to irradiation, have often been unwilling to accept the simple one-hit–one-effect interpretation first put forward by Dessauer in 1922. The symposium reported on here has shown, however, that while the target theory cannot be narrowly applied to all biological effects, there is much reason to believe that when the chains of events preceding them are better analyzed, the end results, in many cases, will be understandable in terms of single ionizing particles or of ion pairs or clusters.

Dr. R. Latarjet (France) reported his experiments on bacteria infected with a known number of virus particles. They show how valuable quantitative work on simple organisms is. If a radiation-induced lesion is due to change in a particular biological element of the cell, and if this element is represented by n units, all of which must be altered if the lesion is to be produced, then the radiosensitivity of the cell will be less as n increases. This situation can be experimentally imitated if a homogeneous population of bacterial cells is infected with a precisely known number of bacteriophage viruses (from 1 . . . . n for each cell), each of which can act as an infective center, and if the virus particle is then looked upon as the sensitive cell element, and loss of infectivity as the lesion. By observing the suppression of infectivity by given radiation doses acting on bacteria containing different numbers of virus particles, it can be shown that each inactivation of a virus is the result of a single hit. Thus the sensitivity of the infected bacteria decreases regularly as the intracellular elements whose alteration will produce the lesion increases.

The same fact emerges from Latarjet's experiments with yeast cells having either one (haploid) or two (diploid) sets of chromosomes. Here the lesion observed is the inability to multiply indefinitely. It had previously been observed that with diploid yeast cells, using X-rays or alpha particles, the proportion of cells showing the lesion gave a sigmoid relationship with dose, indicating that two hits were required, regardless of ion density. The haploid yeast cells derived from them gave one-hit curves. They were also much more sensitive and showed irreversible lesions, which would be expected on genetic grounds. The important point here is the difference in response of cells having two sensitive elements, or conversely only one, in this case the chromosome or chromosome part necessary for cell multiplication.

The quantitative results of these and similar experiments leave no room for doubt that the end results (lesions)

chosen for observation are closely connected with the primary action of the radiation. What is this primary action? For the answer to this question, we find some guidance in the chemical effects of radiation on solutions which contain some of the molecules and radicals present in living cells.

One of the results of irradiation of aqueous media is the production of active oxidation systems, and, with X-rays, the presence of oxygen greatly enhances this effect. It seems that the oxygen molecule has its influence at the level of the primary effect of the ionization. It would thus be possible to ascribe the primary lesion to the oxidation of some molecule whose alteration produces the observed change in the cell. Evidence from several sources supports this general interpretation.

Effect of the presence of oxygen on radiobiological damage. It has been observed in a large number of experiments, covering such widely different materials as bacteria, fungi, and mammalian tissues, that radiation damage is greater in the presence of oxygen than in its absence. *Dr. John Read* (Great Britain) reported his work on seedlings of *Vicia faba*, where the growth of the primary root provides a sensitive measure of radiation damage. When roots were X-rayed in water containing dissolved oxygen, the damage for all doses was greater, by a factor depending on concentration, than when oxygen was replaced by nitrogen, argon or hydrogen. Similar effects of oxygen tension on radiation damage in bacteria were discussed by *Dr. A. Hollaender* (U. S. A.), who finds that the survival rate when X-irradiation is carried out in O_2-saturated media is about three times that when the media is saturated with N_2. The oxygen effect has been described by others for chromosome damage in *Tradescantia* (*1*) and for gene mutation frequency in *Drosophila* (*2*).

Protective effect of reducing agents. It has been argued that if the primary change is produced by oxidizing agents, any other molecule which competes as an electron donor with the one whose alteration will produce the lesion, will protect this sensitive molecule. The protective action of certain added solutes is well known; an example is afforded by the behavior of aqueous solutions of strychnine, whose toxic effect is lost under irradiation, probably through its oxidation to genostrychnine. The presence in the solution of such reducing agents as $NaNO_2$, $Fe(SO_4)_3$, $SnCl_2$ and glucose protects the strychnine from loss of toxicity, although closely related nonreducing agents have no effect.

Glucose deserves particular mention here since its protective effect has been experimentally proved in animals, and Hollaender has shown that bacteria previously grown in broth containing glucose are thereafter less radiosensitive than bacteria grown in ordinary broth. Latarjet interprets these results as due to the loss under irradiation from glucose of some hydrogen which combines with the oxidizing agents to produce H_2O_2, and thus prevents these agents from combining with the sensitive molecules. It follows, as Latarjet has in certain cases observed, that an increase in H_2O_2 production would be accompanied by a decrease in the biological effect of the irradiation.

Recovery through destruction of primary oxidizing agents. If the oxidizing agents produced by ionization can be inactivated before they have reacted with the sensitive molecule, then protection against the lesion will result through a process of recovery.

This possibility led Latarjet to investigate the effect of catalase on the reaction of bacteria to ultraviolet light. He found that *E. coli* of two strains (B and K-12) are more resistant to UV if

enriched in catalase by previous growth on a medium of high catalase content, and that the degree of resistance is greater with high than with low doses of UV. Furthermore, using strain K-12, Latarjet found that the administration of catalase *after* irradiation with UV also had a reactivating effect when the bacteria, before incubation, had been exposed to visible light (which alone would have only a slight effect), although he could not repeat satisfactorily Monod's previous observation (*3*) that post-treatment with catalase alone causes reactivation.

The length of time which can elapse between irradiation and successful application of catalase depends on the temperature, and is as much as 2 hours at 37°. Such a long time lag indicates, if the recovery hypothesis is correct, that the primary action of the radiation is the production of relatively stable molecules. But the danger of oversimplification in interpreting results is exemplified by other work on *E. coli*.

While catalase, or catalase plus visible light, may reactivate strain K-12 after UV, this response is not seen in strain B under the same conditions, although B is strongly reactivated by visible light alone. There is evidence from other sources also that reactivation is greatly dependent on the metabolic condition of the cell. Furthermore, no case has so far been reported of photo reactivation after X-ray irradiation. Hollaender also noted the inability of heat to reactivate *E. coli* after X-rays, although it is successful after UV.

Latarjet's experiments have been outlined here in some detail because they describe quantitative results on simple cells, and because they illustrate one hypothesis of the mode of action of radiations, namely, that the primary lesion is the oxidation of a sensitive molecule. Although interpretation on a molecular level is not quite as easy when specific biochemical cellular constituents of known importance are considered, much suggestive work has been done on these lines also.

Dr. A. Forssberg (Sweden) has applied the tracer technique to the quantitative analysis of radiation effects on certain compounds. It has already been shown by Hevesy and others that radiation depresses the synthesis of desoxyribonucleic acid, a compound found in cell nuclei and concerned in chromosome and gene reproduction, and that the effect can be achieved indirectly by irradiating adjacent tissue. Forssberg finds also that the fat, protein, and carbohydrate metabolism are markedly influenced by moderate doses of X-radiation, and that these responses are altered by the presence of certain "protective" substances such as cysteine, which is one of several amino acids known to decrease radiosensitivity (*4*).

Hollaender and his co-workers at Oak Ridge have studied the effects of certain chemicals, and particularly amino acids, on the radiosensitivity of several types of single cells (bacteria, paramecia, fungi and cells of higher animals growing in culture). These effects are often very striking and must eventually be fitted into any general picture of the biological effects of radiation, but at present their relationship to the initial lesion remains obscure due to our slight knowledge of the cellular role normally played by these molecules or their products or by the molecules with which they react.

It is now well established that radiations of longer wavelength (heat, infra-red and visible light) affect the response of cells to X-rays and to UV. Hollaender and his colleagues report that treatment with infra-red rays of 1,000 A.U. (1.2 ev), either before or after X-radiation, causes an increase in the amount of radiation damage in *Aspergillus*, *Tradescantia*, and *Drosophila*. The infra-red treatment has

no effect when used singly, and does not act by raising the temperature. Furthermore, the time interval between the two treatments can be as long as 60 hours in *Tradescantia* pollen mother cells.

The length of time after irradiation during which the damage it causes can be reversed provides information as to the stability of the chemical changes which have been induced, and further work on this point can be expected to yield valuable results. A question of parallel importance is that of the space relationships which exist between the initial lesion and subsequent steps in the chain of events.

If the altered molecule can diffuse and produce its effect in another part of the cell, then the volume sensitive to one ionizing particle is increased according to the extent of that diffusion. This point was emphasized by *Prof. B. Rajewsky* (Germany). He found that the germination of certain fern spores and the pollen of digitalis and lupin is unaffected by liquid air temperatures. If X-rayed at such temperatures, these cells suffer very much less radiation damage than if X-rayed at ordinary temperatures. If, however, they are dried beyond a certain point, their radiosensitivity increases. Apparently a large fraction of the action of the radiation (60–80%) is dependent on temperature, and the classical target theory must be modified to take into account the diffusion of matter and energy. The diffusion must be very rapid since it was found that spores irradiated at ordinary temperatures and plunged immediately afterwards into liquid air show virtually as much radiation damage as those maintained at the initial temperature. Rajewsky and his colleagues estimate that the diffusion factor causes a thousand-fold increase in the effective sensitive volume of the target.

A source of confusion in radiobiological literature and discussion has been the different meanings attached to the terms *target* or *hit* theory. These terms are in common use to describe actions of radiation which may be due to a single ion pair liberated within a target, a single particle crossing a target, or a single particle passing near, but not through, a target. They do not provide for any distinction between these different possibilities.

To avoid ambiguity, *Dr. L. H. Gray* (Great Britain) suggests a new nomenclature: *Monotopic* describes an action in which the biological change in a cell is the result of the dissipation of energy which is strictly localized in one small region. It does *not* distinguish between dissipation in the biological structure itself and dissipation in the surrounding medium. Similarly, *ditopic* (or *polytopic*) actions are those in which energy must be dissipated in two (or more) localized regions. Clearly, a monotopic action will usually be the result of a single particle, but since the term does not specify that this must be the case, its use instead of less precisely defined expressions would make possible a clearer exchange of ideas.

The field of radiobiological research is characterized, perhaps more than any other, by the necessity for collaborative effort between physicists, chemists, and biologists. This symposium, as well as the proceedings of the Sixth International Congress of Radiology of which it was a part, has shown how productive such efforts have already been in supplying, however tentatively, some of the links in the chain of events. Its completion clearly depends upon the energy with which such work can be pursued.

BIBLIOGRAPHY

1. N. H. Giles, H. P. Riley, *Proc. Natl. Acad. Sci.* **35,** 640 (1949)
2. W. K. Baker, E. Sgourakis, *Proc. Natl. Acad. Sci.* **36,** 176 (1950)
3. J. Monod, A. M. Torriani, M. Jolit, *Compt. rend.* **229,** 557 (1949)
4. A. M. Patt, E. B. Tyree, R. L. Straube, D. E. Smith, *Science* **110,** 213 (1949)

Recent Applications of Neutron Diffraction

Particular advantages of neutrons over X-rays as research tools are emphasized so that readers can evaluate the ideas and methods presented for application to their own problems

By A. H. WEBER

Department of Physics, Saint Louis University, St. Louis, Missouri and Argonne National Laboratory, Chicago, Illinois

THE BRAGG REFELCTION of neutrons (coherent elastic scattering) is a physical phenomenon which has been investigated quite thoroughly, theoretically and experimentally, in recent years. Researches in this field are continuing and new experimental data will be forthcoming.

The diffraction of neutrons has been utilized in studying several types of problems in which X-ray diffraction methods have failed or have produced nondefinite results. Wollan and Shull have written (*1*) a comprehensive discussion of the field, with special emphasis on their own work at Oak Ridge National Laboratory. This general summary has been well supplemented by D. J. Hughes (*2*), who detailed the neutron researches, including some diffraction work, at the Argonne National Laboratory. Repetition of the material of these two summaries is avoided here, except where briefly necessary for completeness. Some of the work of the diffraction group at Argonne is specifically included, however.

Crystal Orientation Studies

In solid-state physics, especially in its applications in metallurgy, the study of crystal orientation effects in polycrystalline materials (such as metals) as produced by processes involving drawing, rolling, extrusion and the like is important. As is well known (*5, 6*) X-ray diffraction yields considerable information in crystal orientation investigations. There are, however, two disadvantages in using X-rays: (*1*) the fairly soft (i.e., long wave length) X-radiation is strongly absorbed in most metals, and consequently (*2*) the specimen under examination is necessarily quite small (typically, but a few mm^3 are examined). Hence substances which have small slow-neutron* absorption can be analysed for crystal orientation by the transmission method, and specimens large enough to avoid a localized condition can be used.

Aluminum and graphite are two materials quite suitable for neutron diffraction investigation. Figure 1 gives the results (*7*) of neutron diffraction studies of crystal orientation in cold-drawn, half-hard aluminum. The data were obtained at the Argonne National Laboratory with the mechanical slow-neutron velocity selector (the "chopper") there available. The operation principle of this simple device is explained elsewhere (*2, 8*).

The principal orientation effects observed for aluminum are shown in Fig. 1; the peaks of the curves are attributed to coherent neutron reflection from the Bragg planes located as

* The wave length of slow neutrons is in the range required for crystal diffraction, in the neighborhood of 1 A.U.

FUNDAMENTAL FORMULAS

Bragg reflection. Bragg reflection of neutrons of wave length λ incident at glancing angle θ_B on crystal planes of spacing d is described by the standard expression

$$N\lambda = 2d \sin \theta_B \quad (1)$$

where N is the order of the reflection. To investigate d values, λ for neutrons must be known and is calculated by the deBroglie wave length formula

$$\lambda = h/Mv \quad (2)$$

where h is Planck's constant, and M and v are the neutron mass and speed respectively. Employing the relation E (kinetic energy) $= \frac{1}{2} Mv^2$, it is possible to express Eq. 2 as

$$\lambda = h/\sqrt{2ME} \quad (3)$$

Finally, inserting the proper conversion numbers—M, $1.67 \times 10^{-24} g$; h, 6.62×10^{-27} erg sec; 1.60×10^{-12} ergs/ev

$$\lambda \text{ (in A.U.)} = \frac{0.285}{\sqrt{E \text{ (in ev)}}} \quad (4)$$

As an example, consider the wave length of the neutrons at the maximum of the energy distribution curve given by Sturm (*3*) for one of the neutron beams of the Argonne National Laboratory heavy-water pile. This maximum energy is about 0.057 ev, yielding directly λ equals approximately 1.2 A.U.

Form factor, F_n. In considering the scattering of either photons or deBroglie waves by a regular physical crystal (a three-dimensional array of scattering centers), one must take into account the phase differences of the wavelets scattered by the individual atoms of the crystal. In X-ray work this is done by calculating the Crystal Structure Factor, F, which is a number summing up (vectorially) for all the atoms (of the unit cell) the scattered wave amplitudes. In neutron diffraction, the procedure is entirely analogous, except that the intensity (proportional to the square of the amplitude) is directly used and is called the Form Factor,* designated here by F_n.

For the general reader, a specific example will distinguish the X-ray Crystal Structure Factor and the neutron Form Factor. Be, a hexagonal close-packed

* Some writers use Form Factor and Structure Factor indiscriminately.

indicated by the Miller indices. (Aluminum is a face-centered cubic structure.) The considerable differences between the curves for parallel and perpendicular neutron beams establish at once the presence of orientation effects. The main features of the cross section curves in Fig. 1 can be explained by assuming preferential orientation of the [111] and [100] axes in the direction of the axis of the original aluminum rod. Figure 2 shows diagramatically the effect of the assumed preferential orientation of these axes on the principal Bragg planes and will be found helpful in understanding the cross section curves. Consideration of Figs. 1*a* and 2 shows that, for the neutrons incident parallel to the rod axis, the [111] and [100] axes alignments in the rod direction produce, respectively, {111} and {200} type

FOR NEUTRON DIFFRACTION

crystal, has two atoms in its unit cell; the origin atom (coordinates: 0, 0, 0) and the "centered" atom (coordinates: $\frac{2}{3}, \frac{1}{3}, \frac{1}{2}$). For a crystal composed of like atoms F, the Crystal Structure Factor is calculated by

$$F = \sum_{h,k,l} \sum_{j} f \exp\left[2\pi N i(hx_j + ky_j + lz_j)\right] \tag{5}$$

where h, k, and l are the Miller indices of the Bragg planes, f is the atomic scattering power, j is summed for all the atoms of the unit cell, and other symbols have the conventional meaning. For the Be hexagonal close-packed unit cell, Eq. 5 yields

$$F_{\text{Be unit cell}} = f_{\text{Be}}\left[1 + \cos 2\pi N\left(\frac{2}{3}h + \frac{k}{3} + \frac{l}{2}\right) + i \sin 2\pi N\left(\frac{2}{3}h + \frac{k}{3} + \frac{l}{2}\right)\right] \tag{6}$$

In turn, for a crystal of like nuclei F_n, the Form Factor is calculated by

$$F_n = K\sigma\left\{\sum_{h,k,l}\sum_{j} \exp\left[2\pi N i(hx_j + ky_j + lz_j)\right]\right\}^2 \tag{7}$$

where σ is the free-atom scattering cross section of the scattering substance and K is a numerical constant depending on the reduced mass of the neutron-Be atom interaction system. Since the summation terms of Eqs. 5 and 7 are identical (note, however, that the latter is squared), Eq. 7 applied to the Be-crystal unit cell yields

$$\begin{aligned}(F_n)_{\text{Be unit cell}} &= K\sigma_{Be}\left[1 + \cos 2\pi N\left(\frac{2}{3}h + \frac{k}{3} + \frac{l}{2}\right) + i \sin 2\pi N\left(\frac{2}{3}h + \frac{k}{3} + \frac{l}{2}\right)\right]^2 \\ &= K\sigma_{Be}\left[2 + 2\cos 2\pi N\left(\frac{2}{3}h + \frac{k}{3} + \frac{l}{2}\right)\right] \\ &= 2K\sigma_{Be}\left[1 + \cos 2\pi N\left(\frac{4h + 2k + 3l}{6}\right)\right] \end{aligned} \tag{8}$$

Also, it should be separately noted from a comparison of Eqs. 5 and 7 that

$$F_n \propto F^2 \tag{9}$$

That is, the Form Factor for neutrons is directly proportional to the square of the Structure Factor for X-rays.

planes perpendicular to the incident neutrons. Hence, there should be the observed large coherent scattering at the long-wave-length cut-off for these planes.

The large value of the cross section near the (222) cut-off (at about 0.015 ev, Fig. 1*a*) at first appears to be an anomaly, since (222) reflection is merely second-order (111) reflection, and since coherent scattering cross section varies directly as λ^2 (i.e., $1/E$), σ_{111} should be about 4.5 times σ_{222}. It is considered, therefore, that the large observed cross section near the (222) cut-off is due chiefly to the nearby (113) and (220) planes. Figure 2 shows the several possibilities for the required (113) and (220) reflections, and the conclusion is seen to be quite reasonable.

Following this line of reasoning, the theoretical σ_{222} was calculated from the

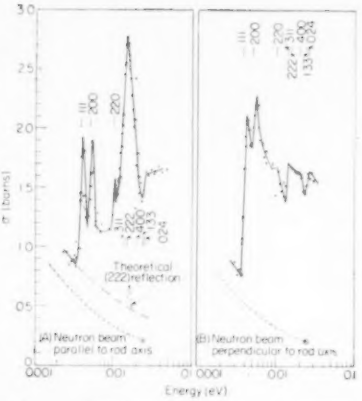

σ (barns)
Energy (eV)
Theoretical (222) reflection
(A) Neutron beam parallel to rod axis
(B) Neutron beam perpendicular to rod axis

FIG. 1. Total cross section vs neutron energy curves for cold-drawn aluminum rod. Specimen size ¾ × 3 × 2¾ in., cut from a 3-in. diameter round rod (From reference 7)

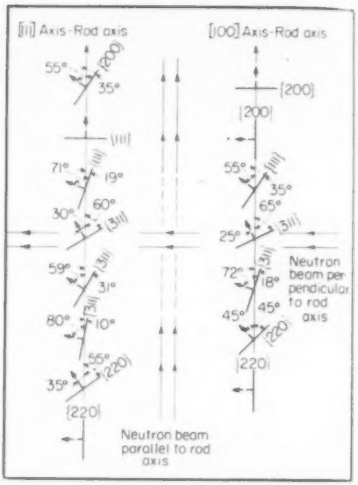


FIG. 2. Orientation of principal Bragg planes relative to [111] and [100] axes assumed in direction of aluminum rod axis and relative to two directions of incident neutrons. Dashed arrows represent perpendiculars to Bragg planes

experimental shape of the σ_{111} peak, assuming that the coherent scattering cross section varies directly as λ^2, and appears as the dashed peak labeled "theoretical (222) reflection" drawn from the dot-dashed absorption and incoherent scattering cross section curve. Separating this experimental curve lowers the prominent peaks near the (222) plane cut-off to approximately the dashed line (at about 2.5 barns).

For neutrons incident perpendicular to the aluminum rod axis, Fig. 1*b* shows the importance of the {111} and {200} reflections. Consideration of Fig. 2 establishes the fact that some only {200} planes are presented perpendicular to incoming neutrons, with the {111} planes at fairly large Bragg angles. It is concluded, therefore, that the dominant coherent scattering is by the {200} planes, with at least half of the steep rise associated in position with the nearby {111} planes being actually caused by the {200} reflection. The dashed line located between about 1.4 and 1.85 barns is an approximate attempt to illustrate this conclusion. It is seen that this assumption diminishes considerably the apparently large {111} reflection. This is probable.

Inspection of Fig. 2 also should emphasize the possibility of limited preferential orientation of the Bragg planes shown about the two orientation axes, [111] and [100]. For neutrons incident parallel to the orientation axes, any limited orientation of Bragg planes about these axes will have no effect, but for the neutrons incident perpendicular to these axes, orientation of planes about the [111] and [100] axes would be important. Perhaps it is also obvious that alignment of crystals preferentially orientated is never perfect, so that the angles shown by Fig. 2 vary somewhat in the actual samples.

Figure 3 is the result of a similar experiment (*9*) with graphite specimens (of about same dimensions as the aluminum) cut from extruded rods.

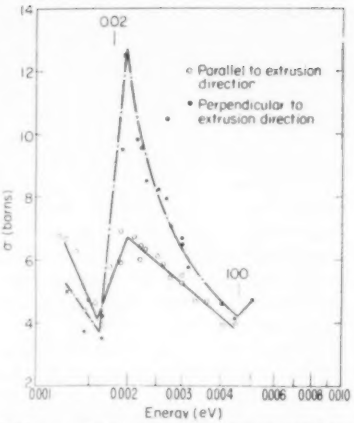


FIG. 3. Total cross section vs neutron energy curves for extruded graphite

The effect of orientations of the (002) planes (the basal planes of the hexagonal unit cells) is clearly evident, since the intensity of the Bragg reflection by (002) planes parallel to the extrusion direction is twice that for reflection from (002) planes perpendicular to the extrusion direction. This means that the hexagonal basal planes in graphite have a preferential alignment parallel or nearly parallel to the extrusion direction that is almost exactly twice the alignment of the same planes perpendicular to the extrusion direction.

Location of Hydrogen in Crystals

Another unique characteristic of the scattering of neutrons by atoms is related to what may be termed the scattering efficiency of light atoms. For X-rays, hydrogen is useless as a scatterer since each hydrogen atom has but one extranuclear electron available for X-ray scattering. But for neutrons, the coherent scattering cross section, of hydrogen, which is directly proportional to scattering efficiency, is comparable to that of the heavier atoms. This is evident from Table 1.

TABLE 1
Approximate Coherent Neutron Scattering Cross Sections

Element	*Cross section, barns*
H	2.0
D	5.0
O	4.2
Na	1.5
Cu	7.3
Mo	5.2
W	3.3
Au	7.5

A promising aspect of neutron diffraction, therefore, is the location of hydrogen and other light atoms in crystal structures. Wollan and Shull and their colleagues have pioneered in this type investigation (*1*) and have recently (*10*) investigated the structure of ice with their neutron diffraction powder method (*1, 11*).

Four theoretical structures for ice, represented by Fig. 4, have been proposed for which the oxygen positions are accurately known by X-ray analysis, but for which the hydrogen positions

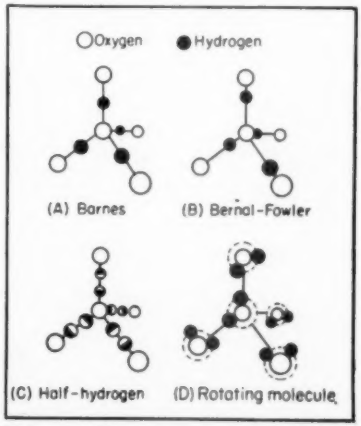


FIG. 4. Structural models used by Wollan and Shull in calculating pattern intensities (Fig. 6) for various proposed structures of ice

are not determinable by X-ray diffraction. In the Barnes model, the hydrogen atoms are at the midpoints of the lines joining neighboring oxygen atoms, and a unit cell contains four H_2O molecules. In the Bernal-Fowler model, there are two hydrogen atoms, one along each tetrahedral line joining oxygen atoms, that are close (about 0.96 A. U.) to each oxygen atom, and a unit cell contains 12 molecules. In the Pauling half-hydrogen model, the crystal can change between two configurations by motion of a hydrogen atom from a position near one oxygen atom to a position near the other along a line joining two oxygen atoms, and the static model, therefore, shows one-half a hydrogen atom in each of the two configurations. In the rotating molecule model, hydrogen molecules rotate about each oxygen atom.

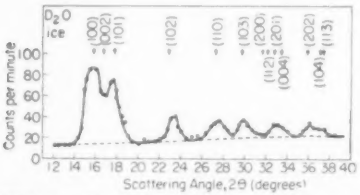


FIG. 5. Neutron diffraction powder pattern of heavy ice (D_2O) observed at −90° C with neutrons of wave length 1.06 A. U. (From reference *10*)

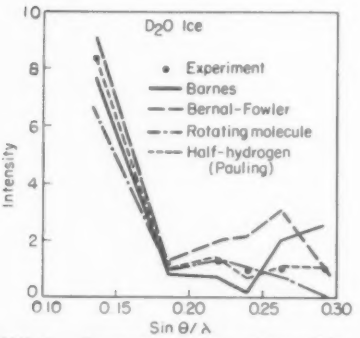


FIG. 6. Comparison of experimental intensities for D_2O ice with those calculated according to the four structural models of Fig. 4 (From reference *10*)

Wollan and Shull, using heavy ice (D_2O) because of the larger coherent scattering cross section of deuterium (5 barns for D, 2 barns for H; Table 1), obtained the curve of Fig. 5 which, combined with the models of Fig. 4, yielded Fig. 6. The excellent agreement of the experimental intensities with the theoretical intensities calculated from the Pauling model definitely establishes the half-hydrogen Pauling model as the basically correct structure for ice.

Order-Disorder Studies in Crystals

Recently (*12*, *13*), Shull and others have successfully investigated by neutron diffraction two types of "order" in alloys. The first of these, termed "chemical" ordering, was found in FeCo and is represented (*12*) by Fig. 7. The advantage of neutron diffraction over X-ray diffraction lies in the difference in neutron scattering amplitudes of the Fe and Co atoms, the former

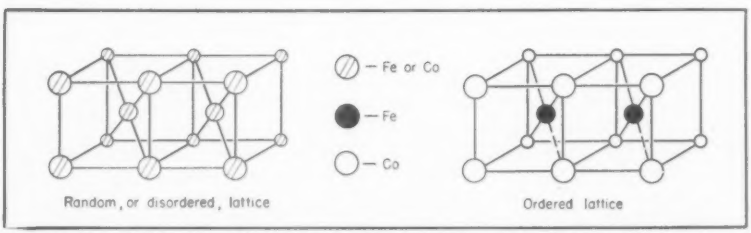


FIG. 7. Order-disorder structure of chemical type observed in FeCo alloy

TABLE 2
X-ray and Neutron Scattering Amplitudes

Substance	*X-rays* ($\sin\theta_B/\lambda = 0.2$)	*Neutrons*
Fe	4.33×10^{-12} cm	0.91×10^{-12} cm
Co	4.54×10^{-12} cm	0.37×10^{-12} cm

being nearly three times the latter, as shown by Table 2 (*12*). This dissimilarity in neutron scattering amplitudes makes it possible to distinguish the two structures of Fig. 7. For X-rays, the scattering amplitudes (Table 2) are so nearly equal for Fe and Co that it is not possible to differentiate the existence of the two structures of Fig. 7 in the FeCo alloy; that is, X-rays cannot reveal the presence of the ordered (super-lattice) structure in FeCo.

Figure 8 shows the neutron diffraction intensity curves obtained with the Wollan and Shull powder diffraction apparatus for ordered FeCo (obtained by slow cooling of the sample from 750° C during 100 hours) and disordered FeCo (obtained by quenching the sample in water from 850° C). It is seen that the extra Bragg reflections (100), (111), and (210) show up clearly in the "ordered" sample, as required by the "ordered" structure of Fig. 7, whereas the "disordered" sample shows only the characteristic body-centered cubic reflections (110), (200), and (211), as required by the "disordered" structure of Fig. 7. Again, X-rays fail to show this super-lattice chemical ordering effect in FeCo.

The second type of ordering observed by neutron diffraction, termed "magnetic" ordering, is not detectable by X-rays in any way. Magnetic ordering has to do with the orientation of the magnetic moments of atoms.

The interaction of the magnetic moments of the incident neutrons with the magnetic moments of the atoms in

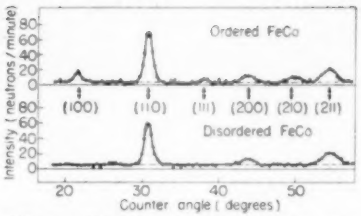


FIG. 8. Neutron diffraction powder patterns observed for ordered and disordered samples of FeCo (From reference *13*)

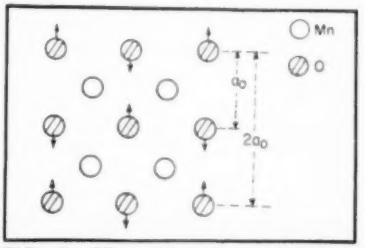


FIG. 9. Magnetic order observed in MnO. Arrows indicate orientation of magnetic moments of oxygen atoms

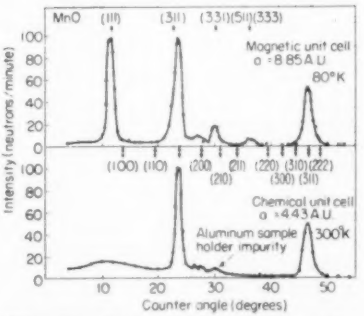


FIG. 10. Neutron diffraction powder patterns observed for magnetically-ordered and chemically-ordered MnO (From reference *13*)

the crystal lattice produces additional diffraction peaks if the magnetic moments are "ordered" as in Fig. 9. The work of Shull and Smart (*13*), shown by Fig. 10, has established the existence of this magnetically ordered structure for MnO at 80° K. From

Fig. 9 it follows that the period of repetition (chemical unit cell edge) is a_0 for chemical ordering but is $2a_0$ (magnetic unit cell edge) for magnetic ordering.

Structure of Glass

There are certain advantages of neutron diffraction over X-ray diffraction for the investigation of structure properties of glass. These advantages are chiefly:

1. For neutrons the intensity vs sin θ_B/λ is theoretically isotropic because the wave length of slow neutrons employed in diffraction experiments is of the order of 1 A. U. This is large compared to the diameter of the scattering nucleus, which is about 10^{-5} A. U., and there are no interference effects inherent in the scattering center for neutrons.*

2. For neutrons the scattering elements in substances (e.g., liquids) having some form of structure are atomic nuclei which are so small relative to the neutron wave length that they are point scatterers. For X-rays the scattering elements are distributed throughout the entire atom. The result of the distribution of scattering elements in the case of X-rays yields a smeared-out type of scattering intensity vs sin θ_B/λ curve (i.e., the groups of scattering elements produce very weak peaks in the intensity curve). For neutrons, in contrast, the point scatterers produce pronounced peaks in intensity vs sin θ_B/λ curves (*14*).

The combination of these two advantages of neutron diffraction can be expected to achieve higher resolution with the use of neutrons in molecular-structure determinations, particularly for larger values of sin θ_B/λ.

A neutron spectrometer, particularly

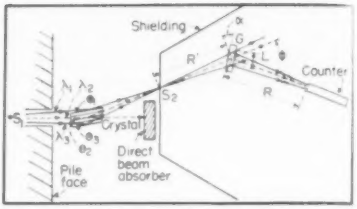


FIG. 11. Chamberlain neutron spectrometer. S_1 and S_2, 3 × ½ in. slits in Cd. S_1 to crystal distance = crystal to S_2 distance = 43.5 in. R, sample G to counter aperture distance, 37.6 cm. R' variable, 0–89.0 cm. The crystal is an aligned bank of calcium fluoride single crystals presenting roughly a 6 × 6 in. area to the thermal neutron flux. G is a boron-free plate-glass specimen

suitable for analysis of liquid or liquid-like structures, has been devised by O. Chamberlain (*15*), who investigated the structure of liquid S, Pb, and Bi. Chamberlain's apparatus avoids the inherent weakness of the neutron powder spectrometers used to study Debye-Scherrer patterns of substances. The difficulty with the straight Debye-Scherrer powder method employed by Wollan and Shull is lack of primary beam flux (i.e., low intensity), necessitating elaborate shielding and long counting times. The Chamberlain neutron spectrometer achieves large flux (high intensity) by sacrificing good resolution in λ and θ_B separately, but achieving good resolution in sin θ_B/λ.

The Chamberlain spectrometer, diagrammed in Fig. 11, permits a direct measurement of the coherent scattering vs sin θ_B/λ. The full spectrum of slow neutrons emerging at the thermal column of the Argonne heavy-water pile constitutes a neutron beam diverging from the "source" slit S_1 and incident on the calcium fluorite crystals as shown. The crystals may be considered as a group of parallel Bragg planes which reflect the various λ's to be convergent at S_2, the focus conjugate to S_1. It is to be noted that although various neutron wave lengths λ_1, λ_2, λ_3 . . .

* For X-rays the atomic scattering factor gives rise to interference effects sharply dependent on sin θ_B/λ because of the distribution of the scattering of extra-nuclear electrons throughout a volume of linear dimension approximately equal to the X-ray wave length.

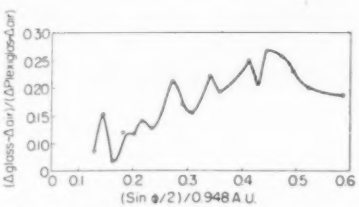


FIG. 12. Neutron diffraction curves for boron-free soda-lime silica glass (6 × 8 × ¼ in. polished plate). Ordinates are in arbitrary units of the ratio of the cadmium differences for scattering, where the neutron scattering is calculated relative to Plexiglas as a reference material, since Plexiglas has approximately constant scattering vs sin θ_B/λ. The angle ϕ is $2\theta_B$. The seven peaks shown occur at d values of 3.42, 2.72, 2.29, 1.82, 1.45, 1.21, and 1.09 A. U., from left to right

are reflected at Bragg angles θ_1, θ_2, θ_3 . . . the group of neutron rays focused at S_2 have a constant sin θ_B/λ, since $N/2d$ is constant for the neutron rays shown.* Passing through the limiting slit S_2, the neutrons fall on the glass sample in a divergent beam so as to nearly bathe the entire glass sample in neutron radiation. The sample and the scattered radiation detector (the "counter") are arranged on a spectrometer that allows precision variation of α and ϕ.

Chamberlain has worked out the theory of this instrument in considerable detail. He has shown that it is necessary to vary α and ϕ simultaneously to preserve sin θ_B/λ essentially constant over the sample length L for each setting of ϕ. In addition, to keep the intensity high, it is necessary to adjust R' and R to obtain a focus of the neutron beam at the counter aperture. In practice, R is kept fixed and R' is varied by moving the entire spectrometer (shown by sample G and counter in Fig. 11) along tracks parallel to the dashed line through the sample center and S_2.

Figure 12 shows one of the neutron scattering curves obtained by this author (*16*) for boron-free plate glass. The curve is for gross scattering only and is uncorrected for neutron attenuation in the sample.

It is emphasized that this result is preliminary in nature. Curves like that shown in Fig. 12 must be subjected to Fourier series analysis to yield radial density distribution curves following somewhat the X-ray methods of B. E. Warren (*17*) for substances (glasses) containing more than one kind of atom. By proceeding with this type analysis, the author is presently continuing the neutron diffraction study of glass with the expectation of obtaining additional information about glass structure.

* Bragg's law is $N/2d = \sin \theta_B/\lambda$.

BIBLIOGRAPHY

1. E. O. Wollan, C. G. Shull, NUCLEONICS **3**, No. 1, 8; No. 2, 17 (1948)
2. D. J. Hughes, NUCLEONICS **6**, No. 2, 5; No. 5, 38; No. 6, 50 (1950)
3. W. J. Sturm, *Phys. Rev.* **71**, 757, Figure 2 (1947)
4. E. Fermi, W. J. Sturm, R. G. Sachs, *Phys. Rev.* **71**, 589 (1947). See p. 592 for an evaluation of K in Be.
5. C. S. Barrett, "Structure of Metals" (McGraw-Hill Book Co., Inc., New York, 1943)
6. W. T. Sproull, "X-rays in Practice" (McGraw-Hill Book Co., Inc., New York, 1946)
7. G. P. Arnold, A. H. Weber, *Phys. Rev.* **73**, 1385 (1948)
8. T. Brill, H. Lictenberger, *Phys. Rev.* **77**, 305 (1950)
9. G. P. Arnold, V. W. Myers, A. H. Weber, *Phys. Rev.* **75**, 217 (1949)
10. E. O. Wollan, W. L. Davidson, C. G. Shull, *Phys. Rev.* **75**, 1348 (1949)
11. E. O. Wollan, C. G. Shull, *Phys. Rev.* **73**, 822 (1948)
12. C. G. Shull, S. Siegel, *Phys. Rev.* **75**, 1008 (1949)
13. C. G. Shull, J. S. Smart, *Phys. Rev.* **76**, 1256 (1949)
14. For example, M. H. Pirenne, "The Diffraction of X-rays and Electrons by Free Molecules," p. 60, Figure 36 (Cambridge University Press, New York, 1946)
15. O. Chamberlain, *Phys. Rev.* **77**, 305 (1950)
16. A. H. Weber. Argonne National Laboratory Reports: Neutron diffraction study of glass (1948); Neutron diffraction in glasses (1950)
17. B. E. Warren, H. Krutter, O. Morningstar, *J. Am. Ceram. Soc.* **19**, 202 (1936); also B. E. Warren, *J. Applied Phys.* **8**, 645 (1937)

Radioisotopes in Pharmaceutical and Medical Studies—II

In this second of a series of three articles, reference is made to both published and unpublished information on tagged barbiturates, amino acids, and other compounds of interest in metabolism studies. Antigens, antithyroid drugs, membrane permeability, and C^{14} toxicity are also discussed

By D. L. TABERN, J. D. TAYLOR, and G. I. GLEASON

Department of Special Research
Abbott Laboratories, North Chicago, Illinois

IN THIS SECOND of a series of three articles, discussion of a wide range of topics is offered to add to the picture of how radioisotopes are being put to use in biology and medicine today.

A brief introduction to the subject of isotopic medicine and an explanation of Abbott Laboratories' "isotope program" for giving assistance to researchers in this field were contained in the first article in this series, which also took up at length the following topics: 1. *Uses of Iodine-131;* 2. *Uses of Phosphorus-32;* 3. *Tumor Localization;* 4. *Other Diagnostic Agents;* and 5. *Tumor Therapy.* In continuation, the topics to be discussed below are: 6. *Barbiturates and Thiobarbiturates;* 7. *Sulfur Amino Acids;* 8. *The Dynamic State,* 9. *Membrane Permeability;* 10. *Antigens and Antibodies;* 11. *Fat Metabolism;* 12. *Thyroid and Antithyroid Drugs;* 13. *Metabolic Studies with Phosphorus-32;* 14. *Isotopes as an Analytical Tool;* 15. *Mechanical Tracing;* and 16. *Toxicity of Carbon-14.*

The numbering of figures and bibliography references is continued from that used in Part I.*

* Part I appeared in the November, 1950, NUCLEONICS, page 3. Part III, which includes discussion of the additional subject of *Drug Metabolism* and conclusions to be drawn from the three-part paper as a whole, will be published in the January NUCLEONICS.

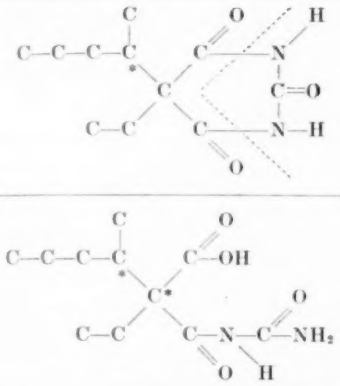
6. Barbiturates and Thiobarbiturates

Our knowledge of the metabolic fate of the barbiturates and thiobarbiturates has benefited much from isotopic studies. Even before C^{14} became popular as a label, we had tagged nembutal with N^{15}. The first publication by Van Dyke, Scudi, and Tabern (*123*) showed that when given orally in therapeutic ranges, 60% of the total N^{15} was excreted in the first 24 hours, but that less than 8% was found in urinary ammonia or urea fractions.

Within the past few months Maynert and Van Dyke have synthesized the expected ring breakdown products, the malonuric acid, the acetyl urea, the acetamid, and the malonamid, and applied the test of isotopic dilution to the

urine containing the actual metabolic products (*124*). The latter three were definitely absent; at first it seemed that the malonuric contained the N^{15}, but conversion to derivatives proved that it was there simply as an impurity.

There was one more possibility—while nembutal contains but one asymmetric carbon, opening of the ring can give rise to two, with the theoretical existence of two racemic forms. Only one was secured synthetically, but the body could have made the other:



On the other hand, amytal, having no asymmetric carbon, could give rise to compounds having but one racemic form. Labeled amytal was made by the Lilly group. Here, too, none of the labeling could be found in the expected breakdown products.

The answer would seem to lie in the isolation by the Columbia group of a metabolite which is apparently 5-ethyl-5-(3-hydroxyl-1-methyl butyl) barbituric acid. We understand that the amytal analog has also been secured (*125*). Such side chain oxidation had been reported many years ago by the Germans, but only when unsaturation existed there. The products from amytal are found to be excreted at less than one half the rate for nembutal, an observation in harmony with the therapeutic duration of action of the two drugs.

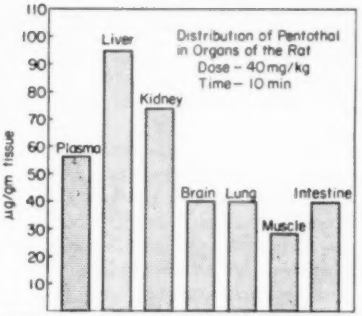


FIG. 7. Pentothal distribution in organs (*129*)

In barbital tagged by us and studied by the Columbia group, there seemed to be no destruction at all. Apparently 3 and probably 4 carbons are necessary before side chain oxidation takes place. Specific experiments were carried out to check the old observations of Keeser that barbital is specifically localized in the diencephalon of dogs and rabbits (*126*). There seemed to be no such localization.

Nembutal, C^{14}-labeled in the urea portion, has been prepared by the Los Alamos Organic Group. No significant amount of labeled $C^{14}O_2$ was eliminated. By chromatography, they showed the presence of five products in the urine but their nature was not further studied (*127*). Kahn has also reported work in this field (*128*).

Left unanswered was the most intriguing question of all: Why does the simple replacement of the oxygen of nembutal by sulfur to give the well-known intravenous anesthetic pentothal cause so marked a change in the duration of action and other properties? For more than a year now, we have been using S^{35}-labeled pentothal in an effort to answer some of these metabolic questions. See Fig. 7.

We found that, as the figure shows,

pentothal was, like barbital, reasonably randomly distributed throughout the body, with the usual somewhat higher concentration in the liver and kidneys (*129*). See also report of Bollman *et al.* (*130*). Certainly there was no preference for the central nervous system, and the disappearance from the blood stream was too prompt to be accounted for by metabolism alone. For instance, in the rat, most of the activity is excreted in the first 24 hours, with a total of 86% being accounted for in urine and feces at the end of 4 days. During 24 hours, 26% was as inorganic sulfate, 6% as ethereal sulfate, 39% as neutral sulfur, and 9% as chloroform extractable. This alone makes improbable a ring breakdown to thiourea, since that product gives rise to little sulfate.

The results from some experiments with monkeys are qualitatively similar, with the $CHCl_3$ extractables going up to 14%.

The chloroform extractable fraction was at first classified as unchanged pentothal on the basis of its ultraviolet absorption, but since the characteristic band at 286 is due to the ring structure, identification was uncertain. The New York University group has supplied another missing link—the isolation of "pentothal carboxylic acid," in which one of the side chain methyls has been oxidized to an acid (*131*). It absorbs at the same ultraviolet wavelength as pentothal, but has a slightly different extinction coefficient. This is obviously reminiscent of the work of Fieser on the napthaquinone antimalarials (*132*). Following large doses, man excretes 10–25% of pentothal in this form. We have injected radioactive pentothal in monkeys and extracted the corresponding tagged compound which has been used, in turn, for a study of its metabolism.

In an effort to resolve the highly complex mixture present in the urine, we used filter-paper chromatography.

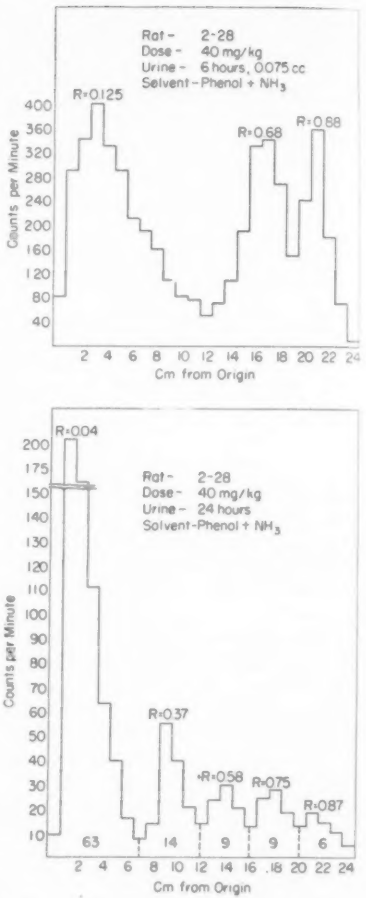


FIG. 8. Pentothal distribution in rat urine after 6 hours and after 24 hours, as determined by paper chromatograms. *R* denotes the R_f value, namely, the distance traveled by the individual band, expressed in terms of per cent of the total distance traveled by the solvent

[Work in this field has also been done by Tomarelli (*133*)]. We were fortunate in having five radioactive compounds on hand for comparison. They were thiourea, methionine, sulfate, sulfide and

thiocyanate, and their R_f values on our paper chromatograms are as follows:

	Phenol Ammonia	*Collidine*	*77% Alcohol*
Thiourea	0.60	0.70	0.62
Methionine	0.79	0.38	0.49
Sulfate	0.05	0.05	0.05
Thiocyanate	0.22	0.84	0.77

The R_f values on sulfide are purposely omitted from the table because in each case several bands were figured. Sulfide is oxidized by air, giving some sulfate, and there is evidence that it also reacts with phenol and possibly with collidine; to present all of this data here would unnecessarily complicate the picture.

The number and relative amounts of the degradation products from pentothal varied with the species and the time after injection. For instance, in one fraction of monkey urine at least nine radioactive compounds were found, four of them extractable by chloroform. One of the latter is unchanged pentothal, and another probably the pentothal carboxylic acid described by Brodie (*131*).

Pentothal distribution in rat urine, as determined by paper chromatography, is shown in Fig. 8. Results too extensive to be quoted here led us to believe that there must be at least two or probably three modes of destruction possible in the body: (1) side chain oxidation, and (2) enzymatic removal of the sulfur.

A third route for which there is admittedly no direct evidence may well be the one the old-time organic chemist would expect, namely, the splitting of the ring with the ultimate liberation of H_2S and NH_3 in line with the in-vitro experiments of Gad (*134*). The fact that the injection of "hot" sulfide gives a chromatographic picture resembling parts of that formed after pentothal makes such a mechanism seem reasonable.

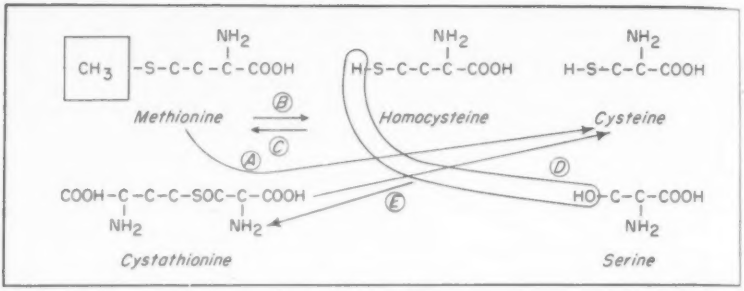
By way of explaining the previously mentioned discrepancy between removal from the blood and destruction, Mark and associates have recently called attention to the role of body fat as a depot, while Goldbaum has stressed the relatively firm combination (first observed by Richards) between pentothal and certain body proteins (*135*, *136*).

Perhaps this "buffering" action of fat stores on pentothal blood concentrations, plus the obvious multiple alternate routes of destruction and elimination, are in part responsible for pentothal's practical safety, even with a known disturbed body function.

7. Sulfur Amino Acids

We have developed a simple method of tagging thiourea, the prime ingredient of the thiobarbiturates. This method consistently gives us a very pure material in a yield of 85%. Specific activities of not less than 12–25 mc/gm have been ample to date, but samples of higher activity can be made as needed.

Thiourea seemed a suitable intermediate for methionine and homocystine, and recently has been adapted for use in the preparation for cystine as well. Several very successful runs have been made starting with 25–30 mc of S^{35} in each case. We have found that, by proper coordination of requests from a number of sources and operation at this level of activity (with the recovery of all activity in the residues), it is possible to make supplies available at a fraction of previous costs, and greatly



below cost of similar C^{14} compounds.

Since only one optical form of most amino acids is utilized by the body, resolution of synthetic samples becomes a real problem. Wood and Gutman have employed a most ingenious method (*137*). If we take, for instance, active benzyl-*d,l*-cysteine and mix it with inactive *l*-benzyl cysteine and repeatedly recrystallize, there is an exchange that results in the formation to a considerable measure of free *l*-active *l*-benzyl cysteine which comes out (in somewhat diluted form) during the purification.

While we are concerned with these sulfur-containing amino acids, it would seem quite appropriate to review briefly what the Cornell and California biochemical groups (and others) have contributed in recent years to our knowledge of the metabolism of these acids.

In 1931, Jackson and Block observed that methionine could replace cystine in the diet of growing animals (*138*). Tarver and Schmidt proved the reality of the biological conversion by feeding labeled methionine and isolating labeled cystine from tissues (*139*). This was recently confirmed for the cystinuric human by Reed *et al.* (*140*).

An inspection of the formulas in the diagram above shows that to do this by straightforward methods would require the apparent removal of one carbon atom from the chain without touching the S or the carboxyl at the ends (*A*).

It has been shown also by isotopic studies that the methyl group of methionine is labile, and that not only can methionine be demethylated to homocysteine (*B*), but that, for the formation of methionine (*C*), the body can utilize them ethyl groups of choline or betaine (*141*). The term "transmethylation" has been applied to these metabolic reactions, and it now appears, incidentally, that B-12 plays a part in the process. To explain the methionine-cysteine conversion more logically, the intervention of cystathionine was evoked, the assumption being that it was formed from homocysteine and amino acrylic acid, and that it, in turn, reduced to cysteine (*D*).

In testing this hypothesis, du Vigneaud and his group shrewdly tried the (*l-l-*) isomer of cystathionine, and found that it (but not the other isomers) could serve as a source of cysteine for body growth. By another ingenious experiment, this same group found that the splitting (*D*) could be carried out by a liver enzyme. The same enzyme went farther and formed labeled cystathionine from homocysteine and serine (*E*) in an over-all yield (*E–D*) of 60%.

Recently Stekol, Weiss, and Weiss fed C^{14}-methyl-labeled methionine and glycine C^{14}-labeled on the amino carbon (*142*). Both showed up in cysteine (isolated as *p*-brom-phenyl mercapturic

acid), presumably through the serine as just indicated.

Again by tracer techniques, but in this case with stable isotopes, the S and the C atoms of methionine were tagged, and it was fed to rats. It was shown that the resultant cysteine from the hair had taken up the sulfur but not the carbon, again clearly indicating the mechanism of the reaction.

The relationship of methyl donating ability to chemical structure has been studied by Maw and du Vigneaud. Dimethyl propiothetin was found to be highly active but S-methyl thioglycollic acid, and several simpler thetin compounds were found quite inactive (*143*).

The methyl group of methionine can give rise to formate and can serve as the source of the beta-carbon of serine (*144*). The methyl group of choline also gives rise to formate, as does the beta-carbon of serine. It has been confirmed that the reverse procedure occurs and that formate is reduced, in some unknown manner, to become the methyl group of methionine.

Along the same line, but still somewhat unexpected, is the report of Mackenzie that formaldehyde is a naturally occurring compound in the animal organism (*145*). It was isolated by several methods following the incubation of C^{14}-labeled sarcosine and liver slices or homogenates. Formic acid and CO_2 were also produced, the former appearing in the urine. Mackenzie has indicated that the methyl group of methionine can become part of sarcosine and part of the adenine of nucleic acids and the porphyrin of hemoglobin as well. Obviously, methyl groups are a highly essential link in metabolic processes.

Further support comes from Siegel and Lafaye (*146*), who find that C^{14} from labeled formaldehyde was converted (by rat liver homogenate) into the beta-carbon of serine more rapidly than from formate and glycerol.

The part that living tissues play in the actual build-up of labile methyl groups has received further confirmation in a unique experiment carried on jointly by the Columbia group and the Lobund Laboratory of Notre Dame. Two rats maintained in a sterile condition were fed D_2O for 23 days and at the conclusion of the experiment, the body choline was isolated. Data showed conclusively that methyl groups had been synthesized by the germ-free animals (*147*). In this same report, information on the influence of B-12 factors on methyl transfers and the role of possible precursors is brought up to date.

A paper by Kinsel and others of a large group at Berkeley represents a decided step forward in the use of isotopes as diagnostic research tools (*148*). They used tracer doses of S^{35}-labeled methionine in the study of protein metabolism in the human and report that, in addition to being safe to use in doses of 25–100 μc, S^{35} has many of the advantages of C^{14} and is free from the serious disadvantage of the 5,000-year half-life of the latter. Metabolically, too, it has certain specific advantages.

Their findings indicate, first of all, that the incorporation of S^{35} into plasma proteins, and its subsequent disappearance and excretion follows, in normals, a typical picture. In patients with chronic liver disease, with idiopathic hypoproteinemia and with Cushings syndrome, significant deviations from normal were observed. (Other S^{35} studies will be discussed in Part III under the subject of *Drug Metabolism.*)

Reference should be made to the protective action of cysteine against radiation effects (*149*).

The demonstration of the ready accomplishment by the body of seemingly complicated reactions (complicated at least for the organic chemist) is but a simple example of the concept which isotopes have done so much to establish. By way of emphasis we would like to

quote in the following section two paragraphs from the Schoenheimer monograph on the subject of "Dynamic State of Body Constituents" (*150*).

8. The Dynamic State

"The large and complex molecules and their component units, fatty acids, amino acids, and nucleic acids, are constantly involved in rapid chemical reactions. Ester, peptide, and other linkages open; the fragments thereby liberated merge with those derived from the other large molecules, and with those absorbed from the intestinal tract, to form a metabolic pool of components indistinguishable as to origin. These liberated molecules are again subject to numerous processes. Fatty acids are dehydrogenated, hydrogenated, degraded or elongated, and thereby continually interconverted. While some individual molecules of these acids are completely degraded, other individuals of the same chemical species are steadily formed from entirely different substances, notably from carbohydrate. Similar reactions occur among the split products of the proteins. The free amino acids are deaminated, and the nitrogen liberated is transferred to other previously deaminated molecules to form new amino acids. Part of the pool of newly formed small molecules constantly re-enters vacant places in the large molecules to restore the fats, the proteins, and the nucleoproteins. Some of the small molecules involved in these regeneration reactions constitute intermediate steps in the formation of excretory products. Part of the nitrogen in mammals travels via the amidine groups of arginine to be either excreted as urea or transferred to glycine to form guanidoacetic acid, creatine, and creatinine. In birds, the nitrogen on its way to excretion does not take the form of amidine groups, but may, for short periods, be present in the purine groups of nucleic acids. Components of an animal are rapidly degraded into specific molecular groups, which may wander from one place to another. The chemical reactions must be balanced so delicately that, through regeneration, the body components remain constant in total amount and in structure. This constancy is not to be taken as an indication that the structural matter of the living organism is inactive and takes little part in metabolism.

"All regeneration reactions must be enzymatic in nature. The large molecules, such as the fats and the proteins, are, under the influence of lytic enzymes, constantly degraded to their constituent fragments. These changes are balanced by synthetic processes which must be coupled to other chemical reactions, such as oxidation . . ."

9. Membrane Permeability

In these days when studies of so-called capillary permeability and fragility are so much in the literature with reference to the actions of rutin, "vitamin P," vitamin C, and now of the steroid hormones like cortisone, we may well consider recent publications from the Carnegie Institute and Tulane. If Na^{24} is given intravenously and proper determinations made of its rate of disappearance, it becomes mathematically possible to show that 60% of the sodium of the plasma leaves the plasma each minute to be replaced by the sodium from the extravascular space (*151*). The corresponding per-

centage for Cl (Cl^{38}) is approximately the same, while that for water is higher, 140% per minute. To interpret these figures in somewhat more dramatic terms, a quantity of water equivalent to the entire weight of the individual is lost from and then replaced into the plasma every 20 minutes. It has been calculated that 50 pounds of salt is thus transferred across the capillary membranes every day.

Iron on the other hand is lost at less than 1% per minute, presumably because it exists there as a globulinate of quite different particle size. The question as to the relation of such permeability to the type of organ, to the condition of the test animal, and to various drug actions would seem to be a very fruitful field for research with isotopes. A good start has already been made; it has been noted that, in the dog, the disappearance curve is not simple but consists of several components. The reason seems to be that in certain tissues like muscle, lung, intestine and liver, there is rapid transfer; in others like skin, bone, tendon, and brain, the rate is relatively slow.

The Quimby group has studied the effect of drugs on diffusion of Na^{24} from blood vessels (*152*). Histamine increased such transfer, but papverine was without action.

Both Na^{24} and K^{42} have been used to study the flow of these ions across the gastric mucosa (frog). The transport of the two from the secretory to the nutrient side was similar, but in the opposite direction, the K moved only 5% as fast. The addition of histamine reversibly increased K transport as much as 10% (*153*, *154*).

It has been shown by C^{14}-tagged plasma (made by lysine feeding of anemic and hypoproteinemic dogs) that carbon is in rapid exchange with the ascitic fluid (*155*).

In passing, we should mention the practical use made of isotopic iron in a pharmaceutical problem during the war. Fe^{59}-tagged hemoglobin was "grown" in the donor dog. Blood was then removed and subjected to the various proposed stages of processing. Later it was injected into a recipient animal, and the survival time of the red cells was determined. Survival of 70% was taken as fair and 90% as excellent. Further studies are in progress.

10. Antigens and Antibodies

No discussion relating to the use of isotopes in medical and pharmaceutical problems could possibly ignore current studies on the antigen-antibody mechanism. It has been mentioned earlier that albumins and globulins may be tagged with iodine without affecting their normal behavior. They can also be tagged with S^{35}, C^{14}, or P^{32}, though much less conveniently (*156*).

Crampton and Haurowitz (*157*) injected rabbits with iodine-tagged antigens and studied the subsequent distribution of activity in the homogenized liver of the animal. The bulk of the deposited antigen was found in the mitochondria fraction, from which fact the conclusion is drawn that these particles are involved in the formation of antibodies.

One theory of anaphylactic shock states that the antigen combines with antibodies fixed to the cells, while the humoral theory maintains that the reaction occurs with antibodies in the circulating blood. By using I^{131}-tagged bovine gamma globulin as an antigen in guinea pigs, Warren and Dixon were able to locate significant antigen concentrations during such shock (*158*). Only the lung and the liver were involved, and since in the latter organ the

histological distribution was the same in sensitized and non-sensitized animals, it was presumably not related to the degree of sensitivity. The sensitized lung, on the other hand, showed twice the affinity of the controls. This increased amount of antigen complex was found in the edematous bronchial fibrous tissue, and the edema appeared to be the principal factor of bronchial obstruction. Labeled crystalline egg albumin behaves similarly. Knox has compared such isotopic tests with quantitative precipitin tests and found good agreement (*159*). Further studies on this subject have been made by Garvey and Korngold (*160, 161*).

It has been emphasized earlier that we know of no *chemical*, except iodine, with a sufficiently specific and firm localization in living tissue to be of practical value against tumor cells. Several investigations have shown that exposure of tumor tissue to its homologous antisera before transplanting destroyed its ability to propagate. It seemed, therefore, that, by tagging, it might be possible to demonstrate some sort of localization and reaction between the malignant tissue and antisera.

Pressman, of the Sloan-Kettering Institute for Cancer Research, has made basic and important contributions in this field (*162, 163*). An antiserum was prepared against egg ovalbumin, iodinated by tracer amounts of I^{131}. By suitable experiments it was demonstrated that it retained its specificity. In a similar manner, "anti rat kidney serum" (which is known to produce physiological changes in the structure of the kidney) was prepared and tagged; upon giving to rats, a definite accumulation of activity was found in the kidney. Tagged antiovalbumin, given under the same conditions, did not show up in the kidney. It was further found that the biological half-life of such activity in the kidney is 3 to 10 times that of the small activity picked up by other organs, which is taken to mean that the antibody is attached to the cells in such a way that tissue enzymes cannot metabolize it. In fact, tenacity of retention (in the glomerulus) of this combination even exceeds that of iodine in the thyroid (*164*).

A very ingenious method was reported for the protection of the specifically active region of the antibody during iodination. This consisted in reacting with the benzoate ion or the benzene arsonate ion. The protecting "hapten" could be subsequently removed by dialysis. For further studies on the precipitin reaction and antibody, see Banks *et al.* (*165*).

Butement, using I^{131}-tagged globulins, found that the quantity of agglutinin for precipitation corresponds roughly to formation of a unimolecular layer of globulin on the bacterial surface (*166*).

11. Fat Metabolism

A discussion of the field of carbohydrate and lower fatty acid metabolism is beyond the scope of this paper, but in view of current nutritional research interest in the use of fat emulsions for caloric feeding, we should like to mention some contributions which isotopic studies have made in this field.

Lerner *et al.* have made very fine emulsions from C^{14}-labeled synthetic palmatin (*167*). Given intravenously (intramuscular absorption is too slow), active $C^{14}O_2$ appeared in the expired air within 1 hour; 36 to 60% of the dose had been thus eliminated within 24 hours. Between 6 and 8% appeared in fat deposits. Furthermore, a large percentage of the labeled fatty acids in the liver and intestines had been utilized for incorporation into phospholipids.

The Boston group used $C^{14}OOH$-labeled trilaurin and found that in 4.5 hours 76% had been exhaled as $C^{14}O_2$, possibly because lauric acid derivatives (12 carbons) are not measurably deposited in adipose tissue (*168*).

Stanley and Thannhauser fed patients an iodized oil (*169*). During the first 24 hours, 50 to 78% of the activity was either collected in the thyroid or excreted in the urine. In fact, its destruction curve paralleled destruction of the C^{14} analog, indicating that iodide liberation results from, or parallels, metabolism for the normal use in the animal. Patients with idiopathic hyperlipemia utilize lipids much more slowly. Rutenburg, Seligman and Fine also found absorption from tissue was slow and was not appreciably increased by hyaluronidase (*170*). They found that more than half of the activity present in the circulation after 24 hours was in the lipid fraction, and 20% as inorganic iodide. Apparently there is storage in lung, liver and spleen, with gradual release over several days. We have supplied such iodized oils and emulsions as tools for use in several quite unrelated problems.

The California group employed C^{14}-palmitic acid and tripalmatin to study fat transfer in the rat (*171*). Within 19–24 hours, some 90% had been absorbed. Of this amount, 70–92% was recovered as the acid from the thoracic duct lymph and 69–84% from the intestinal lymph. These figures, obviously, do not completely rule out alternative modes of transfer.

12. Thyroid and Antithyroid Drugs

Isotopes have made a definite and valuable contribution in another field, the antithyroid drugs. Thiouracil and its methyl and propyl homologs were introduced on the basis of simple biological experiments wherein the animal growth rate, or the thyroid weight, was taken as a criterion of suppression of thyroid activity. It was obvious, however, that serious species differences were present.

In this connection, Astwood and his group began experiments on human beings—an expedient made possible by the nontoxic nature of tracer doses of I^{131} (*172*). A standard dose of activity was given and the exact thyroid uptake curve for that patient was determined. When its slope was established, a definite dose of the drug under test was given; if active, the "pickup" decreased or stopped entirely for a longer or shorter period of time. It was found that not propyl thiouracil but mercapto imidazole is the most active compound, and apparently the latter is now in clinical trial (*173–176*). See Fig. 9 on the next page for some test results.

13. Metabolic Studies with Phosphorus-32

Phosphorus plays such an important part in so many biological processes and the properties of P^{32} are so favorable for experimentation that an extensive (and sometimes confusing) literature has developed. Since Kamen's book "Radioactive Tracers in Biology" (*177*) has an excellent chapter devoted to the details of reported experiments, and Hevesy (*178*) and Chaikoff (*179*) have written excellent reviews, only a few remarks directly bearing on our subject will be made here.

P^{32} is absorbed to a high degree when injected and to varying degrees when given orally. In addition to going

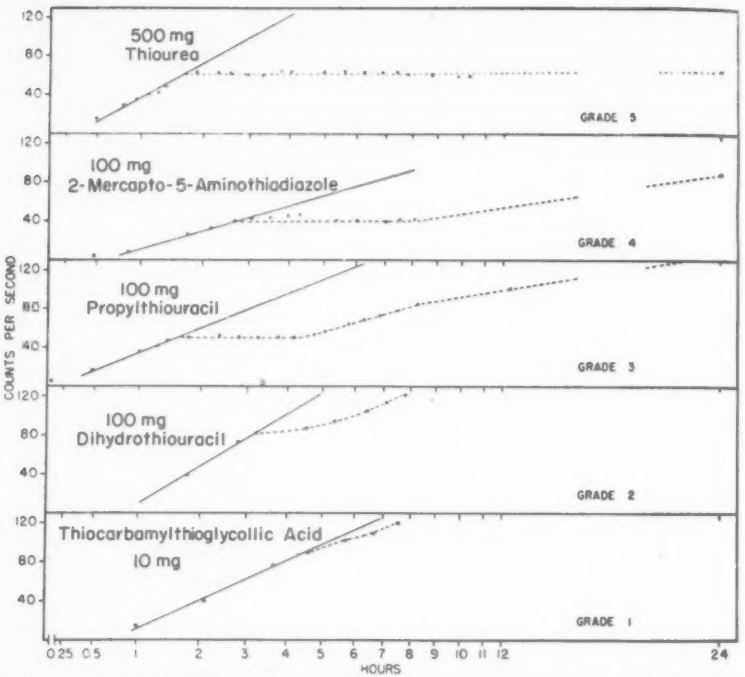


FIG. 9. Tests showing how the uptake of radioiodine by the human thyroid is influenced by the administration of "antithyroid agents" (*173*)

rapidly into extracellular space and into bone, it is metabolized into phosphate esters of the hexosephosphate type, into the nucleic acid and nucleoproteins, into phospholipids, etc. It is possible to prepare phosphorylated intermediates of varying "energy levels," enzymatically and biologically, and it is with perfection of these techniques that a great amount of current work is concerned, particularly at the biological division laboratories at Oak Ridge (*180–183*). In general, such bound phosphate compounds do not exchange in vitro with inorganic phosphate, so that any such change observed represents some metabolic process. The ability of any protein to incorporate P^{32} is a measure of its metabolic turnover. The thymus nucleoprotein has an especially rapid turnover.

In phospholipids, P^{32} holds on one side an organic base such as choline and on the other a complex alcohol, and as such it is not exchangeable. Phospholipids are normally prepared in the liver but may be synthesized also by the kidney and intestine.

Of considerable value in medicine is knowledge concerning the mechanism by which lipo-tropic substances, such as choline and betaine, prevent or relieve fatty liver. This appears to be primarily a stimulation of phospholipid turnover, and can be measured by suitable P^{32} studies (*184–187*).

Cayer and Cornatzer reason that, since plasma phospholipids are likewise

made in the liver, measurements made on the newly formed plasma components should mirror the liver activity. They have such a study in progress (*188–191*).

Pihl and Bloch using C^{14}-labeled acetic acid as a precursor have shown that phospholipids (of the liver) are not especially necessary precursors of neutral fats (*192*).

The uptake and turnover of phosphorus appear to be low in all phosphorus-containing fractions of normal nerve tissue. In contrast, regenerating nerve about one week after section shows a much greater uptake in all fractions (*193*).

The University of Southern California group has used P^{32} and I^{131} in an effort to study the mechanism of virus action (*194*). When a virus (GD-7) was mixed with minced brain, the uptake of P^{32} was markedly stimulated during the period of maximal virus propagation. The virus-containing tissue had an increased ribonucleic acid P content and a decreased desoxyribonucleic picture. There was also increased incorporation of glucose fragments in the protein fraction and decreased incorporation in the lipid fraction of the injected tissue. CO_2 uptake did not seem to be influenced. P^{32} uptake has been studied by Graham (*195*).

It has been shown that phospholipids may be absorbed in various stages of hydrolysis, varying from the intact molecule to inorganic sulfate (*196*).

Of particular interest is the fact that malignant tissues take up P^{32} somewhat more rapidly than do most normal tissues, except those concerned with its metabolism. At least at first the major portion of the activity is in nucleoprotein. For instance, the Harvard group has found that the rate of P^{32} turnover by gastric carcinoma is at least 45% greater than by normal gastric mucosa. This picture was attributed to a 124% increase in turnover in protein phosphorous, a 45% increase in turnover in lipid phosphorous, but no change in acid-soluble phosphate. It should be emphasized, however, that the phosphorous total content remained normal (*197*).

The influence of hormonal inbalance offers another fertile field for research. For instance, P^{32} uptake by slices of grey matter increased 50 to 400% after hypophysectomy because of an increased rate of phosphorylation.

The paper chromatography of P^{32}-labeled phospholipids has always been difficult, and the bands observed probably do not always represent entities. O'Leary and Neuman have presented a resumé of present information (*198*).

A Russian publication reports that camphor accelerates P^{32} exchange 17–20 times in the brain and only 5 times in the muscles. This, it is stated, is the cause of camphor convulsions of the central nervous system. Tetraethyl ammonium iodide has an opposite effect; that is, it slows P^{32} exchange (*199*).

Also of considerable potential value in our field is the production of biological mutations due to chromosome breakage induced by P^{32} (*200*).

Mention should be made of the use of P^{32} in parasitology by McCoy, Downing, and Van Voorhis (*201*). They found that *Trichinella spiralis* larvae in the encysted stage exchange ions through the cyst wall and probably, therefore, carry on an active metabolism

14. Isotopes as an Analytical Tool

The extreme sensitivity of radioisotope measurements would seem to make isotopes ideal as analytical tools. As such, they seem neglected (*202*).

Tobias and the California group have made use of "activation analysis," with

neutrons from a reactor as the activator (*203*). If an element capable of absorbing neutrons is thus irradiated, it becomes activated to a degree proportional to the time of exposure. If a set of samples is thus treated and covers the expected range of concentration, simple counting of all samples suffices to give the concentration of the unknown. Actually, of course, all other absorbing elements present will be similarily activated; thus recourse must be had to chemical methods, and absorbers must be used in counting in most practical cases. The almost unbelievable sensitivity of the procedure is evidenced by the fact that only 10 cc of blood was needed to show concentrations of gold of the order 10×10^{-6} grams in an entire human body.

This method should have interesting possibilities in the quantitative study of trace impurities that influence pharmaceutical stabilities in nutritional problems and in the labeling of pharmaceutical specialties (*204, 205*).

Thyroid iodine, and thyroid P^{32} uptake have been used as a measure of thyrotropic hormone efficiency, and of sex hormone clinical efficiency (*206, 207*).

Dorfman has made ingenious use of K^{42} for the assay of the adrenal cortical steroids (*208*). The hormone is given in oil followed one hour later by 10–200 μc of the isotope. The activity of the urine is determined six hours later to calculate the difference between the injected and excreted K^{42}. Amounts as small as 10 μg of desoxycorticosterone may be thus determined.

I^{131}-tagged fibrinogen has been used as a measure of proteolytic enzyme activity (*209*). The tagged fibrin clot, held at *p*H 6.3–8.8, was made the substrate for the enzymes plasmin and trypsin; the amount of iodine liberated into the supernatant served as a very sensitive measure of enzyme concentration.

Perhaps the most extensively studied isotope reagent is pipsyl chloride (*p*-iodo-I^{131}-phenyl sulfonyl chloride) proposed by Keston and the New York University group and elaborated upon by Udenfriend and associates at Washington University (*210–214*). By the original technique, the unknown amino acid mixture (a protein hydrolysate, for instance) was "pipsylated" in good yield (and on a milligram scale, if necessary). Known inactive pipsyl acids were added as carriers to prevent undue losses, and the resultant products isolated by partition, by chromatography, or by crystallization. From the data, a reasonable quantitative assay of the amino acids can be derived.

More recently, the use of S^{35}-labeled amino acids as "indicators" has been introduced. The radiation characteristics of the two "tags" are so different that it is easily possible to determine the quantity of each present.

After the appropriate separation procedures, the mixture of the *known* S^{35}-labeled pipsyl amino acid, A, and the I^{131}-labeled pipsyl derivative of the supposedly same amino acid, B, is chromatographed. The resultant "band" is cut into sections across the strip. If all sections of the band have the same S^{35}-I^{131} ratio, one may feel confident that but one compound is present and that acid A is the same as acid B. This promises to be a very precise tool for biochemists. We are currently engaged in perfecting the techniques, for preparing the labeled compounds required.

Raben reacted an unknown minute iodine concentration, as iodate, with an excess of I^{131} of known specific activity. The resultant I_2 was extracted with CCl_4 and counted to give the original iodate concentration (*215*).

Wieland proposes a new method for determining α-amino acids on chromatograms and ionopherograms (*216*). Cu^{64} (12.8 hours) is spread by capillarity

over a ready-made chromatogram, or the paper is impregnated beforehand with copper acetyl acetone. Assay is by counts or radioautography.

15. Mechanical Tracing

One of the early uses of isotopes in pharmaceutical problems was for tablets or capsules containing a suitable radioactive salt ($Na^{24}Cl$) and covered with the enteric coating under test (*217*). Appearance of sodium in the circulation was, of course, a sign that the tablet had disintegrated.

Cyr *et al.* (*218–220*) have used isotopes in a number of other pharmaceutical problems, among which was a comparison of the absorption of NaI from 37 different ointment bases. Teeth of rats were made radioactive and the effect of various mouth washes on them was observed. Detergents containing S^{35} were prepared and the amount remaining on the skin determined.

Talbot, Quimby, and Barach have used aerosols containing Na^{24} to measure sodium retention and rate of appearance in the blood stream (*221*). The count, measured above the chest, went up immediately after inhalation, and decreased quite rapidly because of absorption of the ionized salt.

Tagged bacteria have been used to study the distribution of the organisms following injection (*222*). More recently, Goldberg and Leif have atomized suspensions of an avirulent strain of *Pasteurella pestis*, the organisms having been previously incubated with P^{32} phosphate. Retention by mice in the respiratory tree following 20 minutes' exposure to the aerosol approximated 30%, while some 85% was found to be retained by the entire body (*223*).

As reported in a European journal, circulation of the cerebrospinal fluid has been examined by the use of thorium X, following injection into the lateral ventricle. The thorium X was found useful diagnostically (*224*), but obviously better isotopes are available in this country for studies of this sort.

Radioautographic methods have been developed for determining the particle size of radioactive aerosols containing an alpha emitter (*225*).

Several groups have labeled mosquitoes by P^{32} or Sr^{89} by growing the larvae on solutions of appropriate concentrations. For whatever it may prove, the females showed twice as much radioactivity as the males. Knowing the activity per mosquito and measuring the activity per "trap" sufficed to determine the extent of migration from various areas. Silkworms injected with tagged nutrients secrete radioactive silk, whose amino acid composition is being studied (*226, 227*).

16. Toxicity of Carbon-14

When C^{14} first became available, it was classified as among the more dangerous isotopes, first, because of its 5,000 year half-life and, second, because indications were that uptake by the bone was considerable (*228*). All evidence since that time has pointed in the opposite direction. Brues, for instance, injected mice with $NaHC^{14}O_3$, and made them rebreathe the expired air for 10 hours (*229*). Less than 2% of the carbon had exchanged and 90% of this was lost within a week.

Skipper, White and Bryan found that

more than 95% of 18 μc of sodium bicarbonate injected into a mouse was excreted in 24 hours, the major portion (94%) being lost within the first four hours by respiration (*230*). After 24 hours, the carbon apparently remained in organic compounds generally distributed in all tissues. It disappeared at a rate dependent upon the metabolic activity of the individual tissue. After 12 weeks, only 0.13% was detectable, with localization mostly in the skeletal muscle. This 18-μc dose represented 0.11 rep for the first 24 hours, and only 0.003 rep in the period 1–3 months. They have suggested 3 μc as the maximum permissible dose in man. We have noted that even the use of organic compounds does not result in much accumulation. Gould *et al.* found the 4-hour cumulative excretion to be 95% for bicarbonate, 87% for acetate, and 86% for succinate (*231*).

When C^{14}-methyl-labeled glycine is injected into mice, up to 70% is lost as $C^{14}O_2$ in the first 48 hours. After 43 days, 5.5% of the injected activity is present; it has an over-all biological half-life of 10.5 days (*232*).

Govaerts (*233*) says, "From these data we may conclude that most of the C^{14} absorbed by the organism as barium carbonate is expired by the lungs as $C^{14}O_2$, and that dangers to those who work with C^{14} are not as great as expected."

BIBLIOGRAPHY

NOTE: References 1–122 were published with Part I of this paper.

123. H. B. Van Dyke, J. V. Scudi, D. L. Tabern, *J. Pharmacol. Exptl. Therap.* **90,** 364 (1947)

124. E. W. Maynert, H. B. Van Dyke, *J. Pharmacol. Exptl. Therap.* **98,** 174, 180, 184 (1950)

125. E. W. Maynert, H. B. Van Dyke, *Science* **110,** 661 (1949)

126. E. Keeser, I. Keeser, *Arch. Exptl. Path. Pharmakol.* **179,** 226 (1935)

127. L. J. Roth *et al.*, *J. Biol. Chem.* **178,** 963 (1949)

128. J. B. Kahn, Jr., *Anesthesia & Analgesia* **29,** 273 (1950)

129. J. D. Taylor, R. K. Richards, D. L. Tabern, *Anesthesia & Analgesia* **29,** 101 (1950)

130. J. L. Bollman *et al.*, *Anesthesiology* **11,** 1 (1950)

131. B. B. Brodie *et al.*, *J. Pharmacol. Exptl. Therap.* **98,** 85 (1950)

132. L. F. Fieser *et al.*, *J. Am. Chem. Soc.* **70,** 3174 (1948)

133. R. M. Tomarelli, K. Florey, *Science* **107,** 630 (1948)

134. I. Gad, *Arch. Exptl. Path. Pharmakol.* **199,** 449 (1942)

135. L. C. Mark, E. Bernstein, B. B. Brodie, *Federation Proc.* **9,** 300 (1950)

136. L. R. Goldbaum, P. K. Smith, *Federation Proc.* **9,** 275 (1950)

137. J. L. Wood, H. R. Gutman, *J. Biol. Chem.* **179,** 535 (1949)

138. R. W. Jackson, R. J. Block, *Science* **74,** 414 (1931)

139. H. Tarver, C. L. A. Schmidt, *Proc. Soc. Exptl. Biol. Med.* **41,** 442 (1939)

140. L. J. Reed *et al.*, *J. Biol. Chem.* **180,** 783 (1949)

141. J. A. Muntz, *J. Biol Chem.* **182,** 489 (1950)

142. J. A. Stekol, K. Weiss, S. Weiss, *J. Biol. Chem.* **185,** 271 (1950)

143. G. A. Maw, V. du Vigneaud, *J. Biol. Chem.* **176,** 1037 (1948)

144. P. Siekevitz, D. M. Greenberg, *J. Biol. Chem.* **186,** 275 (1950)

145. C. G. Mackenzie, *J. Biol. Chem.* **186,** 351 (1950)

146. I. Siegel, J. Lafaye, *Proc. Soc. Exptl. Biol. Med.* **74,** 620 (1950)

147. V. du Vigneaud, C. Ressler, J. R. Rachele, *Science* **112,** 267 (1950)

148. L. W. Kinsel *et al.*, *J. Clin. Invest.* **29,** 238 (1950)

149. D. E. Smith *et al.*, *Proc. Soc. Exptl. Biol. Med.* **73,** 198 (1950)

150. R. Schoenheimer, "Dynamic State of Body Constituents," p. 63–64, rev. D. Rittenberg *et al.* (Harvard Univ. Press, Cambridge, Mass., 1942)

151. L. B. Flexner, D. B. Cowie, G. J. Vosburgh, *Proc. Cold Spring Harbor Symposium Quant. Biol.* **13,** 88 (1948)

152. I. Mufson, E. H. Quimby, B. C. Smith, *Am. J. Med.* **4,** 73 (1948)

153. E. E. Crane, R. E. Davies, *Biochem. J.* **45,** 23 (1949)

154. F. Morel, M. Marois, *Compt. rend. soc. biol.* **143,** 464 (1949)

155. F. McKee *et al.*, *J. Exptl. Med.* **91,** 115 (1950)

156. F. J. Dixon, S. Warren, *Am. J. Med. Sci.* **219,** 414 (1950)

157. C. F. Crampton, F. Haurowitz, *Science* **112,** 300 (1950)

158. S. Warren, F. J. Dixon, *Am. J. Med. Sci.* **216,** 136 (1948)

159. W. C. Knox, *Federation Proc.* **9,** 336 (1950)

160. J. S. Garvey *et al.*, *Bacteriol. Proc.*, p. 74 (1950)

161. L. Korngold *et al.*, *Bacteriol. Proc.*, p. 75 (1950)

162. D. Pressman, *Trans. New York Acad. Sci.* **11,** 203 (1949)
163. D. Pressman, L. A. Sternberger, *J. Am. Chem. Soc.* **72,** 2226 (1950)
164. D. Pressman, *J. Immunol.* **63,** 375 (1949)
165. T. E. Banks *et al.*, *Nature* **165,** 111 (1950)
166. F. Butement, *J. Chem. Soc. Sup. Issue 2,* p. S-408 (1950)
167. S. R. Lerner *et al.*, *Proc. Soc. Exptl. Biol. Med.* **70,** 384 (1949)
168. R. P. Geyer, J. Chipman, F. J. Stare, *J. Biol. Chem.* **176,** 1469 (1948)
169. M. H. Stanley, S. J. Thannhauser, *J. Lab. Clin. Med.* **34,** 1634 (1949)
170. A. M. Rutenberg, A. M. Seligman, J. Fine, *J. Clin. Invest.* **28,** 1105, 1110 (1949)
171. B. Bloom *et al.*, *J. Biol. Chem.* **184,** 1 (1950)
172. M. M. Stanley, E. B. Astwood, *Endocrinology* **41,** 66 (1947)
173. R. W. Rawson *et al.*, *J. Pharmacol. Exptl. Therap.* **93,** 240 (1948)
174. D. A. McGinty *et al.*, *J. Pharmacol. Exptl. Therap.* **93,** 246 (1948)
175. D. A. McGinty, M. L. Wilson, *Endocrinology* **44,** 546 (1949)
176. D. A. McGinty, *Ann. New York Acad. Sci.* **50,** 403 (1949)
177. M. D. Kamen, "Radioactive Tracers in Biology," p. 184–200 (Academic Press Inc., New York, 1947)
178. G. Hevesy, *Ann. Rev. Biochem.* **9,** 641 (1940)
179. I. L. Chaikoff, *Physiol. Rev.* **22,** 291 (1942)
180. P. Lowrence, C. E. Carter, U. S. Atomic Energy Commission AECU-395 (Nov., 1949)
181. W. E. Cohn, U. S. Atomic Energy Commission AECU-430 (Dec., 1949)
182. J. Sacks, U. S. Atomic Energy Commission AECU-466 (Mar., 1950)
183. E. W. Sutherland, T. Z. Posternak, C. F. Cori, *J. Biol. Chem.* **179,** 501 (1949)
184. I. Perlman, I. L. Chaikoff, *J. Biol. Chem.* **127,** 211 (1939)
185. I. Perlman, I. L. Chaikoff, *J. Biol. Chem.* **130,** 593 (1939)
186. I. Perlman, N. Stillman, I. L. Chaikoff, *J. Biol. Chem.* **133,** 651 (1940)
187. D. B. Zilversmit, C. Entenman, I. L. Chaikoff, *J. Biol. Chem.* **176,** 209 (1948)
188. D. Cayer, W. E. Cornatzer, *Science* **109,** 613 (1949)
189. D. Cayer, W. E. Cornatzer, *J. Clin. Invest.* **27,** 528 (1948)
190. D. Cayer, W. E. Cornatzer, *Gastroenterology* **14,** 1 (1950)
191. W. E. Cornatzer, D. Cayer, *J. Clin. Invest.* **29,** 534, 542 (1950)
192. A. Pihl, K. Bloch, *J. Biol. Chem.* **183,** 431 (1950)
193. D. Bodian, D. D. Dziewiatkowski, *J. Cellular Comp. Physiol.* **35,** 155 (1950)
194. M. E. Rafelson, Jr., R. J. Winzler, H. E. Pearson, *J. Biol. Chem.* **181,** 583, 595 (1949)
195. A. F. Graham, L. McClelland, *Can. J. Research* **E28,** 121 (1950)
196. C. Artom, M. Swanson, *J. Biol. Chem.* **175,** 871 (1948)
197. J. Schulman, Jr., M. Falkenheim, S. J. Gray, *J. Clin. Invest.* **28,** 66 (1949)
198. J. O'Leary, W. F. Neuman, Abstract 1959, *Nuclear Sci. Abstracts* **4,** 316 (1950)
199. G. Y. Gorodisskaya, *Doklady Akad. Nauk. S. S. S. R.* **69,** 833 (1947)
200. T. J. Arnason, E. Cumming, J. W. T. Spinks, *Science* **107,** 198 (1948)
201. O. R. McCoy, V. Downing, S. Van Voorhis, *J. Parasitol.* **27,** 53 (1941)
202. H. M. Clark, R. T. Overman, U. S. Atomic Energy Commission MDDC-1329 (Sept., 1947)
203. C. A. Tobias, R. W. Dunn, *Science* **109,** 109 (1949)
204. H. W. Kohn, E. Tompkins, U. S. Atomic Energy Commission ORNL-390 (Mar., 1950)
205. M. Berenbom, *Abstracts of Am. Chem. Soc. Meeting* (Chicago), p. 39C (1950)
206. U. Borell, H. Holmgren, *Acta Endocrinol.* **3,** 331 (1949)
207. J. H. Müller, H. Aeppli, *Experientia* **5,** 297 (1949)
208. R. I. Dorfman, *Proc. Soc. Exptl. Biol. Med.* **70,** 732 (1949)
209. N. R. Shulman, H. J. Tagnon, *J. Biol. Chem.* **186,** 69 (1950)
210. A. S. Keston, S. Udenfriend, R. K. Cannan, *J. Am. Chem. Soc.* **68,** 1390 (1946)
211. A. S. Keston, S. Udenfriend, M. Levy, *J. Am. Chem. Soc.* **69,** 3151 (1947)
212. A. S. Keston, S. Udenfriend, R. K. Cannan, *J. Am. Chem. Soc.* **71,** 249 (1949)
213. A. S. Keston, S. Udenfriend, M. Levy, *J. Am. Chem. Soc.* **72,** 748 (1950)
214. S. Udenfriend, *Federation Proc.* **9,** 240 (1950)
215. M. S. Raben, *Anal. Chem.* **2,** 480 (1950)
216. T. Wieland *et al.*, *Naturwissenschaften* **36,** 280 (1949)
217. K. Lark-Horovitz, H. R. Lang, *Nature* **147,** 580 (1941)
218. G. N. Cyr *et al.*, *J. Am. Pharm. Assoc., Sci. Ed.*, **38,** 615 (1949)
219. D. M. Skauen *et al.*, *J. Am. Pharm. Assoc., Sci. Ed.* **38,** 618 (1949)
220. A. E. Jarvis *et al.*, *J. Am. Pharm. Assoc., Sci. Ed.* **38,** 206 (1949)
221. T. R. Talbot, Jr., E. H. Quimby, A. L. Barach, *Am. J. Med. Sci.* **214,** 585 (1947)
222. J. O. Ely, *J. Franklin Inst.* **234,** 500 (1942)
223. L. J. Goldberg, W. R. Leif, *Science* **112,** 299 (1950)
224. J. Gerlach, *Zentr. Neurol. Surg.* **9,** 206 (1949)
225. J. A. Leary, F. J. Fitzgibbon, U. S. Atomic Energy Commission AECD-2791 (June, 1949)
226. D. W. Jenkins, C. C. Hassett, NUCLEONICS **6,** No. 3, 5 (1950)
227. P. F. Hahn, V. H. Haas, A. Wilcox, *Science* **111,** 657 (1950)
228. W. Bloom, H. J. Curtis, F. C. McLean, *Science* **108,** 45 (1947)
229. A. M. Brues, D. L. Buchanan, *Proc. Cold Spring Harbor Symposium Quant. Biol.* **13,** 52 (1948)
230. H. E. Skipper, L. White, Jr., C. E. Bryan, *J. Biol. Chem.* **180,** 1187 (1949)
231. R. G. Gould *et al.*, *J. Biol. Chem.* **177,** 295 (1949)
232. G. L. Nardi, *Science* **111,** 362 (1950)
233. J. Govaerts, *Science* **111,** 467 (1950)

An End-Window Alpha Scintillation Counter for Low Counting Rates*

The instrument described here has proved to be efficient and reliable in actual operation. It combines high geometry, a large sample cup, low background, and stability over long counting periods. Both design and operation are discussed

By CLIFTON W. REED†
Chief, Instrument Section, Atomic Energy Project
University of California, West Los Angeles, California

TO BE USABLE at low counting rates, an end-window alpha scintillation counter must be designed to meet certain requirements. In addition, certain other features are desirable. The criteria established for and met by the present instrument are as follows:

1. It must use a 1½-in. diameter sample cup and still provide reasonably high counting geometry.

2. It must be insensitive to beta and gamma radiations.

3. It must have a low background counting rate.

4. It must be standardized in electrical and mechanical design and in operating technique to conform with standard beta-gamma G-M counters.

5. It must provide easy chamber decontamination.

6. It must provide stable operation over long periods (in the order of a month) of continuous operation.

7. It must be insensitive to normal line noises and voltage variations.

A prototype of the unit to be described used an early RCA C-7132 photomultiplier tube, the experimental forerunner of the 5819, as the photosensitive detector. Later models use the 5819. This type of tube offered the best possibility of simultaneously satisfying all of the points specified. The large end-window photocathode provides high optical efficiency and at the same time lends itself well to vertical mounting in the standard fashion used for mica-window G-M tubes. It also results in high counting geometry with the 1½-in. sample cup chosen. The high optical efficiency, high current gain, and relatively low tube noise obtainable with the 5819 type of photomultiplier tube result in high signal-to-noise ratios essential for stable, high-efficiency counting at zero noise background rates.

Previous work‡ with alpha scintillation counters lent precedence to the use of a Scotch tape screen of Patterson type B zinc-cadmium sulfide powder for converting alpha-particle energy into visible light. The simplicity of this type of screen is most evident to the operator. New screens can be quickly made and installed in the event of contamination.

The completed alpha scintillation counter includes a centrally located sample chamber, amplifiers, gate and scaling

* This paper is based on work performed under Contract No. AT-04-1-GEN-12 between the U. S. Atomic Energy Commission and the University of California at Los Angeles.

† Present address: R-C Scientific Instrument Co., Playa Del Rey, Calif.

‡ B. Cassen, C. W. Reed, L. Curtis, L. Baurmash. An alpha scintillation counter for health physics and dust study applications, UCLA-14 (1949).

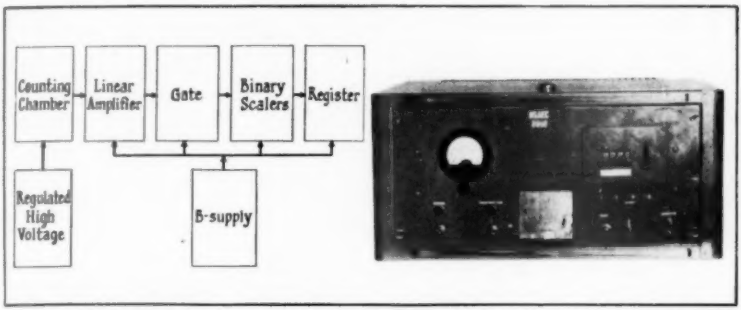


FIG. 1. Block diagram shows basic circuit relationships; front view of complete alpha scintillation counter shows position of chamber and other parts. Interior of counting chamber is shown in Fig. 3

circuits, and register. A view of the instrument and a block diagram of the circuit is given in Fig. 1. The counting chamber and linear amplifiers form the most important part of the scintillation counter.

Counting chamber. An interior view of the chamber is given in Fig. 3. The housing is made of sheet stainless steel and has a sliding front panel to allow access to the interior. The door opens sufficiently to allow replacement of tube, screen, sample holder, and sample trays without having to disassemble the whole housing. This feature makes decontamination of the counting chamber relatively simple.

Much effort was necessary to insure light-tightness of the chamber. Gaskets and light traps were used around the sliding door and the tube mounting plate.

The upper portion of the housing contains the tube socket, mounting plate, and the resistance network for providing dynode operating potentials. The photomultiplier tube is suspended vertically from the tube mounting plate at the top of the chamber and is centered on the chamber center line.

Directly below the tube is mounted the sample-tray holder, which is notched for holding a screen and tray. The screen, tray and dish are shown in Fig. 2;

FIG. 2 (Above). From left to right are the fluorescing screen, sample holder with stainless-steel dish, and a sample made up on Scotch tape according to the method described in the text

FIG. 3 (Left). Interior of counting chamber. Note position of tube, screen, and sample

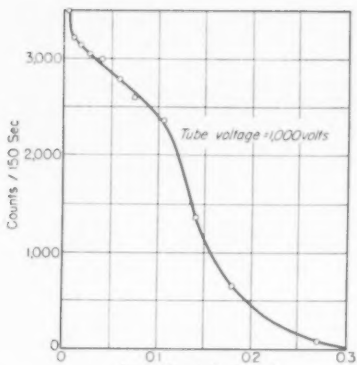
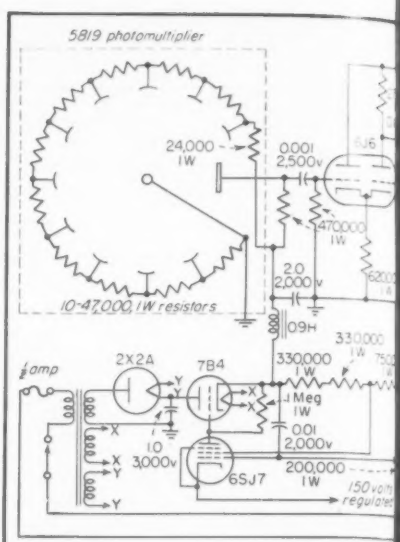


FIG. 4. Counting rate as a function of input sensitivity, showing distribution of pulse heights

FIG. 5. Circuit diagram of the alpha scintillation counter



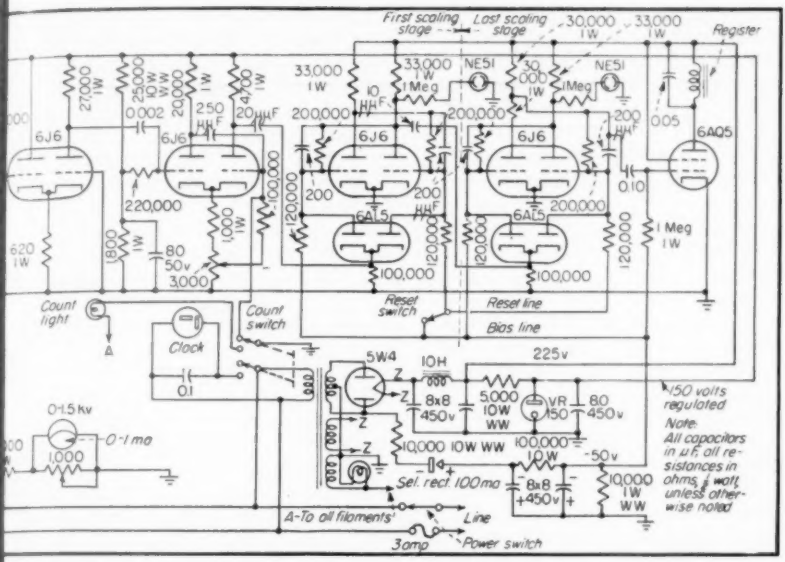
the screen is mounted about 2 cm below the end of the tube. The sample is mounted on a tray and placed in the next groove, 0.5 cm below the screen. Actual distance between the screen and the bottom of the cup is 0.65 cm.

Making a screen is an extremely simple process. A piece of three-inch wide Scotch tape is placed on the screen holder plate. This plate has a 2¼-in. diameter hole which forms an edge around the exposed sticky tape surface. Powdered zinc-cadmium sulfide, Patterson type B, is sprinkled on the sticky surface, and the holder is shaken with a sideways motion until there is a thin layer of the powder deposited all over the surface of the tape. The excess powder is then poured off, and the screen is ready for use.

The reproducibility of screens was tested from a standpoint of counting geometry. Ten different screens were made up. Each was used to count the same alpha source. The standard error of the distribution of screen geometry factors was found to be less than 2%. This fact makes possible several tricks to increase counting geometry and reduce background counting rate. The methods are discussed under "Operation."

The 5819 photomultiplier has an S-9 response peaking at about 4,800 A. U. in the blue-green portion of the spectrum. Response to the yellow-green scintillations produced by impingement of alpha particles on the zinc-cadmium sulfide screen is approximately 85% to 90% of the maximum.

With tube, screen and geometrical configuration used in the counting chamber, a wide variation of pulse heights is encountered at the output of the photomultiplier. Pulse heights range from about 0.3 volts to 0.01 volts when the tube voltage is set at 1,000 volts. The distribution of pulse heights may be gleaned from a study of Fig. 4. The graph is a plot of counting rate of a particular sample as a function of input sensitivity. Differentiation of the curve would result in a pulse-height frequency distribution curve having a



maximum at 0.15 volts. This corresponds to that point of inflection occurring at 0.15 volts on the curve of Fig. 4. A second point of inflection is noted at 0.025 volts; at that sensitivity setting the threshold of noise occurs. Obviously, an operating point must be chosen with less than 0.025 volts sensitivity, but sufficiently sensitive to obtain good counting efficiency. The ratio of the two voltages at the points of inflection is a good measure of the merit of the counting system, and is dependent on the tube sensitivity-to-noise ratio. Most photomultiplier tubes give better sensitivity-to-noise ratios at about 80 to 90 volts per stage, equivalent to a total voltage of about 900 to 1,000 volts across a 5819 tube, than they do at higher applied voltages.

Although the screen does scintillate on absorption of beta or gamma radiation, the light intensity is lower than an alpha scintillation by a factor of at least 100, and distinctions can easily be made between the pulses.

Linear amplifiers. Because pulses occurring in the photomultiplier are in the order of 0.01 volts and the gate circuit cannot be held stable at an input sensitivity of 0.01 volts, it is necessary to provide a gain of at least ten. An additional factor of ten is needed to take care of sensitivity differences in photomultiplier tubes.

A variable gain amplifier having a maximum gain of 100 is provided to allow adjustment for optimum operating conditions. The control is chassis-mounted. Once it is adjusted for a particular phototube, it need seldom be readjusted unless repairs are needed or a new tube is installed. Replacement of the tube should be rarely necessary since there is no theoretical limit to its life.

Circuitry. The block diagram of Fig. 1 indicates the basic circuit arrangement. The actual schematic is given in Fig. 5. A standard type of regulated high-voltage supply is used with some additional filtering to provide a noise-

free d-c line to the photomultiplier tube. Dynode operating potentials are fixed by a dividing network in the chamber in the ratio of 100 volts per stage and 50 volts between dynode 10 and plate.

A scintillation occurring in the screen as a result of alpha-particle impingement causes an output pulse from the photomultiplier tube of approximately 50 μsec decay time. Rise time is limited by the amplifiers to approximately 5 μsec. Variations of over 30 to 1 occur in pulse height, as is indicated by Fig. 4. With a gate pulse width of 100 μsec, counting without correction for coincidence losses is possible at rates up to several hundred per second.

The linear pulse amplifiers, used to provide additional over-all gain, are of the twin-triode grounded-grid type. Extremely good linearity over a wide input voltage range is obtained. This is helpful in making pulse-height distribution curves or in plateau plotting. The amplifier is also very stable and has a high-frequency 3-db point of approximately 200 kc.

High-pass coupling circuits are used between stages to give a low-frequency 3-db point of approximately 1,000 cycles. Stray 60-cycle and low-frequency line noises are thus attenuated.

The gate circuit is a twin-triode, cathode coupled, one-shot multivibrator with provision for sensitivity adjustment. Gate sensitivity can be varied from 0.1 to several volts. It is normally adjusted to about one volt. This control is not essential, but, together with the amplifier gain control, it gives wide latitude to over-all control of sensitivity. With amplifier gain at 100 and gate sensitivity setting of 0.1, all pulses appearing at the photomultiplier tube plate of 0.001 volts or higher may be detected. This is usually well into the tube noise region when the tube voltage is above about 800 volts. Such extremely high sensitivity is not needed for alpha scintillation work, as may be noted from the pulse height or bias curve of Fig. 4. Maximum input sensitivity of 0.01 volts is obtained when the gate sensitivity is adjusted to one volt.

This basic circuit has also been used in beta and gamma scintillation counting studies. In fact, this instrument is easily converted to scintillation counting of any type by merely arranging the desired screens or crystals in their proper positions under the photomultiplier tube window and then readjusting over-all circuit sensitivity with the controls provided.

Operation

Establishing correct operating conditions is one of the most important problems in working with scintillation counters. Several families of curves should be run before arriving at the final operating settings of tube voltages and amplifier gain.

Noise and beta-gamma counting thresholds as well as the alpha counting plateau must be determined before making a decision as to correct operating conditions. Individual tests can be performed to establish all these facts.

The first step is to obtain the alpha counting plateau. A low value of gain is selected as a parameter, and the counting rate of a sample is plotted against tube operating voltage just as is done in obtaining Geiger-Müller counter plateaus. A reasonably high-activity alpha sample is used to facilitate plateau plotting. Several more plateaus are plotted using higher values of gain. The family of curves will appear somewhat as in Fig. 6. The gain setting giving the broadest plateau (150 to 200 volts) is usually chosen to perform succeeding tests. The higher the over-all signal-to-noise ratios of the detecting system, the broader will be the plateaus. Magnetic fields and earth fields are known to have a definite effect on the plateaus and should be minimized by proper shielding.

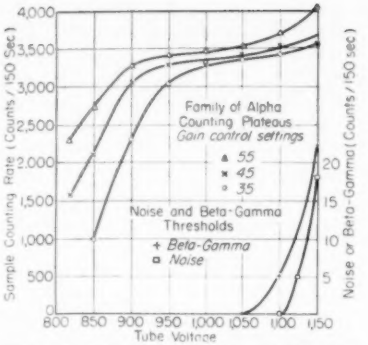


FIG. 6. Curves used in establishing operating conditions for the alpha scintillation counter

With gain setting established by this method, a noise curve is plotted to obtain the noise threshold. For this test the screen is removed. The threshold of noise is best established by starting with a high value of tube voltage and observing noise counting rate at each setting as the voltage is decreased. A noise curve is also plotted in Fig. 6.

A third test should be conducted to establish the beta-gamma counting threshold. It is run in a similar manner to the noise curve, but both a screen and an active beta sample are in place in the chamber. The beta-gamma counting threshold should occur at a slightly lower voltage than the noise threshold.

The best operating voltage may now be chosen. A voltage is selected on the alpha counting plateau which will allow for variation in the high-voltage supply, but which is, at the same time, below the noise and beta-gamma threshold voltages. For the curves shown in Fig. 6, the voltage should be between 950 and 1,050 volts. A value of 1,000 volts at a gain setting of 45 will give reliable counting in spite of small changes in high-voltage supply or amplifier gain. At the same time, noise background is zero for all practical purposes, and no counts caused by beta or gamma emitters will be observed.

A saving in time in arriving at proper operating conditions is made by preparing an alpha-beta sample with a fairly high ratio of beta to alpha disintegration rates. This sample is used to establish the alpha plateau and beta-gamma threshold simultaneously. The latter is evidenced by the sharp rise in counting rate at higher voltages. A noise curve is still needed to make sure the noise threshold voltage is not lower than the beta-gamma threshold and thus masking it.

When optimum conditions have been arrived at, it will be found that background counting rates of two to three counts per hour are encountered. About two counts appear to be caused by alpha-emitting atoms in the air (radon, thoron, etc), and the third count by a contaminant in the screen.

One of the most important features of the scintillation alpha counter is its extremely low background counting rate. In fact, it is so low that it is difficult to establish exactly. With a background of 2 cph, it is necessary to count for a 48-hour period to establish the rate with a standard error of 10%. What has been done in practice is to run backgrounds overnight and count samples during the day whenever the activity of the sample allows short runs of about eight hours or less. Daily and overnight backgrounds are recorded and continuously accumulated to obtain an accurate average. Low-activity samples in the order of background are sometimes counted over weekends in order to arrive at a usable figure.

Standards made up in a $\frac{1}{8}$-in. deep, $1\frac{1}{2}$-in. diameter stainless-steel cup establish a counting geometry of 23% when 0.65 cm screen-to-sample spacing is used. Higher geometries are possible by moving the sample closer to the screen. If the sample is made up on a plate or disk rather than the stainless

steel cup, geometries approach 32% as the sample is brought nearer the screen. Over-all counting efficiency of the screen is estimated to be at least 64% and is probably slightly higher.

The sample may be placed very near or in direct contact with the screen without contaminating the screen if a thin protecting film of rubber hydrochloride or collodion is placed over the sample. Little loss in geometry occurs when the films are reasonably thin. Films can be prepared from a solution of rubber hydrochloride in chloroform. A drop of the solution on water will form a thin film which is easily picked up on a wire loop and then attached by surface tension to the sample.

An alternative method for obtaining geometries comparable to those already given consists of attaching individual screens to each sample. With the proper care in making and mounting the screens, it is possible to reproduce screen efficiencies with a standard error of 2% as previously mentioned. Advantage of this method is best made in counting very low activity samples of approximately 3 or 4 cph or less. Use of an individual Scotch-tape screen sealed to each sample not only results in high geometry, but also in a lower background counting rate. The rate is reduced by the reduction in the volume of air to which the phosphor is exposed. Alpha-emitting gases such as radon and thoron which are present in air, although in very small amounts, account for about 1½ to 2 cph in background counting rate. With a sealed screen the alpha particles from the sample are absorbed at one surface by the sample cup or disk and at the other by the Scotch-tape film itself. Therefore, if little or no air is trapped between sample and screen, maximum counting geometry can be achieved with less than 1 cph background. When working at background levels of activity, it becomes impractical to try to evaluate disintegration rates any more accurately than to within 10 to 50% standard error. The 2% error in screen geometry factor is of negligible importance in this case.

In special cases where the sample material is very finely powdered, it is possible to sandwich it between two screens, allowing geometries approaching the screen efficiency estimate of 64%. Backgrounds should be about 1 to 2 cph for the two screens. Scintillations occurring in the top screen will be recorded, whereas not all, but a large fraction of, the scintillations occurring in the bottom screen will be transmitted through the semitransparent top screen and will be recorded. A reflector properly placed below the bottom screen increases the recorded number of scintillations from the bottom screen. Geometries of 64% have been obtained in this manner. Further studies of this type are being carried out.

A statistical analysis will reveal the definite advantages of increasing counting geometry and decreasing background counting rate when dealing with low activities.

Assuming a background rate of 2 cph, a counting period of 24 hr and a desired standard error of 10%, it is possible to make measurements as low as 2.6×10^{-12} curies or 0.26 $\mu\mu$c on production samples made up in the 1½-in. cup and counting at 23% geometry.

Making the assumption that the lowest sample counting rate detectable must yield a count equal to the background rate, the lowest disintegration rate the sample may have must be about 9 d/hr or about 0.067 $\mu\mu$c when counted at 23% geometry and a background of 2 cph.

* * *

Acknowledgment is due Mr. G. Streit for equipment construction and testing; Mr. L. Silverman and Mr. W. Dunn for sample preparation and valuable suggestions in operation of the equipment; and to Mrs. P. Rich for gathering operation data.

Physical Considerations in Applying Cobalt-60 to Cancer Therapy*

Dosage problems are discussed. A practical unit of source strength and a method for calibrating sources are given. The Paterson-Parker method of dosage control in therapy has been adapted to Co^{60}, and the required graphs are included here

By G. W. CALLENDINE, Jr.,† J. L. MORTON,† and W. G. MYERS‡
The Ohio State University Medical Center, Columbus, Ohio

RADIOTHERAPISTS have become increasingly aware of the possibilities of applying the various artificial radioisotopes to the treatment of malignancies. One of the most promising of the isotopes is cobalt-60, an isotope of cobalt produced by bombarding inert cobalt metal (Co^{59}) with neutrons in a nuclear reactor. Some of the basic ideas leading to the application of this isotope have already been reported (*1*).

A program was instituted October, 1948, in the Department of Radiology here to investigate the possibilities of applying Co^{60} to cancer therapy as an adjunct to the present tools available to the radiotherapist.

Two of the first requirements in using Co^{60} were to develop a system for determining the strength of the individual sources of activity (in our case small cartridges made from 3.0-mm lengths of 0.5-mm diameter cobalt wire irradiated to desired intensities) and to develop a system of distribution of the activity throughout the tumor to secure uniform treatment. It is convenient to set up units of intensity for the sources which have significant meaning when correlated with radiation effects delivered to tissue. When Co^{60} is used in the form of needles, the system of dosage distribution, that is, the actual working procedures in treatment, should be as similar as possible to radium techniques to enable radiotherapists to convert to Co^{60} and still utilize the knowledge and experience gained from using radium.

Units Used in Therapy

Clinically, the therapist is interested in the ionization effects of the irradiating material in the tissue being irradiated. A unit expressing the ionization absorbed by tissue is the roentgen. In other words, the therapist desires to know the number of roentgens delivered to and their effect within the tissue. Biological effects of radium have been approximately correlated with roentgen dosages.

In radium therapy the practical unit is the milligram (mg). Although this is a unit of mass, it is used interchangeably as a unit of radiation quantity. This is a result of the definition§ of the

* This investigation, conducted by the Ohio State University Medical Center, was assisted by the joint program of the Office of Naval Research and the Atomic Energy Commission through a contract with the Ohio State University Research Foundation.

† Department of Radiology.

‡ Fellow in Bio-Physical Research, Department of Medicine.

§ The International Commission on Radiological Units recently redefined the *curie* so that it is independent of radium. It is the quantity of *any* radioactive nuclide in which the number of disintegrations per second is 3.700×10^{10}.

Comparison of Ionization of Ra and Co^{60}

Substance	*Quantity*	*Filter*	*Disintegration Rate (per sec)*	*Ionization Effect (mrhm)*
Radium	1 mc = 1 mg	0.5 mm Pt	3.7×10^7	0.84
Cobalt-60	1 mc	0.5 mm Al	3.7×10^7	1.35*

* Calculated from the energy absorbed in 1 cm^3 of standard air at a distance of 1 meter from a 1 mc source of Co^{60}, using 1.16 and 1.33 Mev as the gamma-ray energies of the disintegrating Co^{60} nucleus (*4*) and neglecting absorption of the air path.

curie as the quantity of radon in radioactive equilibrium with 1 gram of radium (*2*). The decay products of radon are also included in this secular equilibrium condition, for it is from their disintegrations that the beta particles and gamma rays are given off, thus producing the qualities which render radium a radiation therapeutic agent.

The millicurie as used in therapy is defined in terms of quantity of radium rather than quantity of radon. Thus 1 mc is thought of as 1 mc or 1 mg of radium. The absolute disintegration rate of radium as recommended by the International Radium Standard Commission is 3.7×10^{10} disintegrating atoms/second/gram of radium (*2*).

The millicurie is carried over to artificially radioactive substances and is now interpreted as the quantity of any substance disintegrating at the rate of 3.7×10^7 atoms per second. It must be recognized that the ionizing effect of the particles or rays as they traverse tissue (energy dissipated in the tissue) is not considered in the establishment of this use of the millicurie.

As it turns out, millicurie amounts of different radiating materials have very different ionizing effects in tissue. For this reason the millicurie is not a satisfactory unit for use in therapy unless one is careful to recognize this distinction. Considerable confusion has already resulted among radiation therapists from use of this unit.

In 1946, Condon and Curtiss suggested the roentgen per hour at one meter (rhm) as a practical unit of energy dissipation (*3*). One thousandth of this unit—the milliroentgen per hour at one meter (mrhm)—seems particularly suited to gamma-radiation therapy because:

1. It is a measure of the ionizing effect of the isotope used regardless of its decay scheme.

2. It is a convenient unit readily measured with an inexpensive ionization chamber.

It is important to stress the difference in roentgen effect between the same millicurie amounts of two radioactive substances. Biologically, the tissue effects of equal amounts, in mrhm, of radium (filtered with 0.5 mm Pt) and Co^{60} (filtered with 0.5 mm Al) are virtually comparable. But, as may be seen from the table on this page, 1 mc of Co^{60} approximately equals 1.62 mc of radium for equal roentgen dosage.

Calibration of Co^{60} Needles

In our group, all thinking is in terms of roentgens. Thus the source strength is in units of mrhm whether radium or Co^{60} is being used. When a shipment of Co^{60} is received from the nuclear reactor, it is necessary to standardize the cartridges before one can use them clinically. This is accomplished very simply.

1. A sample of Co^{60} of the same general strength as the unknown units

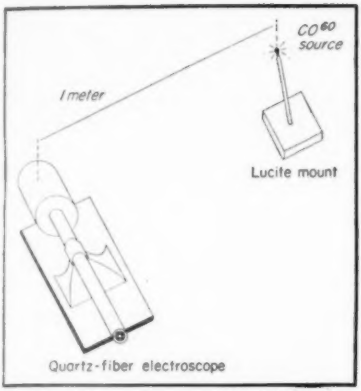


FIG. 1. A convenient method for determining the strength of Co^{60} sources in mrhm

is shipped to the National Bureau of Standards in Washington, D.C. for standardization by them in mrhm.

2. After this sample is returned, it is set up at a distance of one meter from a quartz-fiber electroscope and the discharge rate of the electroscope determined; that is, the electroscope is calibrated in milliroentgens per hour against this standard (Fig. 1).

3. The known sample is replaced by the unknown cartridges. These are then calibrated. The source strength is thus determined in mrhm.

4. Decay curves are set up for each group of source strengths by plotting the logarithm of activity against time, using 5.3 years as the half-life of the Co^{60}. One such curve is shown in Fig 2. The strength at a future time is then determined from the decay curve.

Calculation of Dosage

Physical principles and clinical procedures have been worked out for radium therapy by Paterson and Parker (*5*) and are well known. When Co^{60} is used in multiple source implants, the techniques can be similar to those using radium. In fact, Co^{60} may be

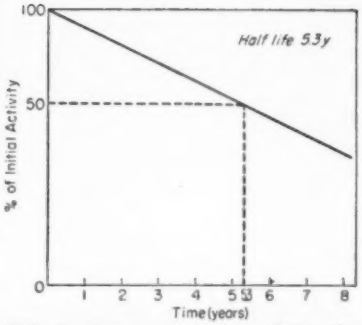


FIG. 2. Decay curves are drawn for each set of similar sources to enable the person calculating dosage to determine source strength at any given time after calibration

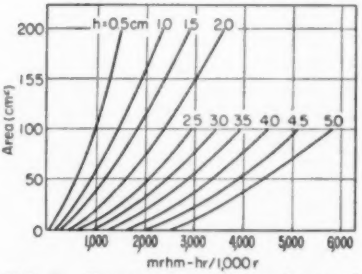


FIG. 3. Dosage curves for surface and mold applications

differentially distributed to approximate the Paterson-Parker theoretical distributions much more accurately than is practical with radium. For this reason it is convenient to use the information secured by Paterson and Parker and to adapt it to Co^{60}.

The only change made in the techniques established by Paterson and Parker is to convert the dosage graphs for use with Co^{60} as the irradiating material. The revised graphs are set up to give directly the amount of Co^{60} (in mrhm) required to give a total dosage of 1,000 r to given areas and volumes of tumor in one hour.

The following conversion equation

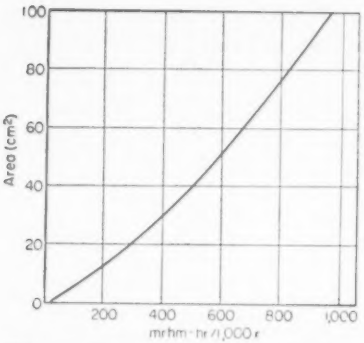


FIG. 4. Dosage curve for single-plane and two-plane implants

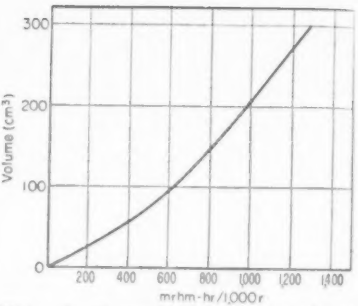


FIG. 5. Dosage curve for volume implants

was used to adapt the Paterson-Parker graphs to Co^{60}

$$\frac{\text{mrhm-hr}^*}{1{,}000\text{ r}} = \frac{\text{mg-hr Ra}}{1{,}000\text{ r}} \times \frac{0.84\text{ mrhm}}{1\text{ mg Ra}}$$

When converted from mg-hr Ra/1,000 r to mrhm-hr/1,000 r, the dosage graphs appear as in Figs. 3, 4, and 5. The three graphs are for use in calculating dosage for treating surface and mold, planar implant, and volume implant tumors respectively. They are used in the same way as conventional Paterson-Parker graphs.

* mrhm-hr required to give a total dosage of 1,000 r.

BIBLIOGRAPHY

1. W. G. Myers, *Am. J. Roentgenol. Radium Therapy* **60,** 816 (1948)
2. M. Curie *et al., Revs. Mod. Phys.* **3,** 427 (1931)
3. E. U. Condon, L. F. Curtiss, *Phys. Rev.* **69,** 672 (1946)
4. E. N. Jenson, L. J. Laslett, W. W. Pratt, *Phys. Rev.* **76,** 430 (1949)
5. R. H. Paterson, H. M. Parker, *Brit. J. Radiology* **7,** 592 (1934); **11,** 252, 313 (1938)

BOOKS

The Nature of Physical Reality (A Philosophy of Modern Physics), by Henry Margenau, McGraw Hill Book Co., Inc., New York, 1950, xiii + 479 pages, $6.50. *Reviewed by Max Born, F.R.S., Department of Mathematical Physics, University of Edinburgh.*

Although the main title of this book stresses one philosophical concept, that of reality, it is actually what the under-title says: an attempt to represent the philosophical foundations of modern physics as a whole. This is an ambitious task; for the separation of the sciences from mother philosophy has been long and thorough. Each sphere has grown enormously and produced its own endless literature, often in a highly technical language. Taking all this into account, I think that the author has succeeded. Each of the 21 chapters is followed by a list of books, recommended as "selective readings," which give an idea of the amount of learning compressed in this volume.

The author is a well-known theoretical physicist; he is entitled to speak about the ideas of physics with the authority of one who has done valuable research work himself.

He writes not only fluently and

clearly, but has a characteristic, often brilliant style, which does not shrink from drastic expressions and jokes. I do not think that he lacks respect for the achievement of Greek mathematicians when he speaks (on p. 133) of "Euclid's famous lullaby" which had lulled mathematicians for centuries into accepting unquestioningly his axioms. To illustrate relativity, he remarks (on p. 153) that a soul, if it moved away from the body at the time of death with the speed of light, would observe the last dying moment as an eternity of bliss or agony. Such entertaining sentences can be found on almost every page.

The real value of the book lies in its liberal, tolerant, reasonable attitude which does not cling to one of the traditional systems nor to the trains of thought just fashionable among the philosophers of science. In the first chapter, which is particularly pleasant reading, the author explains these general convictions, the most important of which is his rejection of positivism, the doctrine which claims to build science without metaphysical principles. There are also some interesting sections on the relations of science to humanities; on the encyclopedic tendencies in science; on the Marxistic interpretation of science, which by clever examples is shown not to be wrong but utterly trivial.

To explain in detail the author's actual philosophy would need much more space than is available here, but an outline may be attempted.

Physics, like every science, starts with the data obtained from sense impressions, for which the term "plane of the immediately given" or, in short, "Nature," is introduced. The results of thinking are called "constructs." In his reasonable, liberal way, the author, however, does not assume a sharp boundary between these two domains. The identification of the "immediately given" with sense impressions, though still widely accepted, seems to me rather doubtful as it is based on an old-fashioned psychology. Modern "Gestalt" psychology teaches that the data of perception consist of whole shapes which cannot in any sense be regarded as additively built from sense impressions. But this is a minor point. Among the constructs are thing-like objects which have properties, and here the author distinguishes between "possessed" and "latent" ones—terms whose meaning becomes clear in later sections.

Constructs are the material for reality, which consists of valid constructs or "verifects." To be valid, a construct has to satisfy certain metaphysical principles and stand the test of verification by experience. The author accepts and describes six principles which he calls metaphysical (not because they hold *a priori* or for all time, but because they represent the most general rules of thinking that have turned out to be useful and fertile). These principles are: logical fertility; permanence and stability; multiple connection; extensibility; causality; and simplicity and elegance.

When a construct has been shown to conform with these principles, it is confronted with experience. The author uses a graphical representation where the constructs are little spheres in a space bounded by a plane representing "Nature." A line connecting a sphere with "Nature" represents a law of correspondence between an immediately given datum and a construct. On the other hand, the sphere (construct) considered is also connected with other spheres (constructs) which together represent a theory. If one of the spheres of this system also has a connection to "Nature," the theory is verified and its constructs become valid and are raised to the rank of reality.

Concerning definitions of scientific notions, the author has a corresponding distinction: Those based on "Nature" through a law of correspondence are

called "epistemic," and those based solely on constructs, "constitutive." Of this distinction, he makes several important applications, for instance, with regard to the functions of probability in science. Here the frequency definition of probability based on counting of actual events is of course the epistemic one, while Laplace's definition through equally probable cases is constitutive. The author thinks that both types of definitions are needed and supplement one another.

From this interpretation of experience it follows that the inherent vagueness of scientific statements is due to "Nature," but not to the system of constructs which, by its definition, always gives sharp results.

The author now considers the actual constructs of physics in more detail. They are of three main types: systems, observables, and states. These words are of course familiar to every modern physicist from Dirac's presentation of quantum mechanics. But Margenau insists that they can also be applied to classical physics, and he surveys for this purpose the whole history of the exact sciences, beginning with space and time, discussing relativity, mechanics of discrete and continuous systems, electrodynamics, thermodynamics, statistical mechanics, and ending of course with quantum mechanics.

This review is interrupted by an interesting chapter on probability where the connection of this notion with the idea of "latent" properties is revealed. The observables of classical mechanics, electrodynamics, and thermodynamics "possess" their values, while, in all the statistical theories, the values of the observables are "latent." In this way he bridges the gulf between classical and quantum theory.

Therefore, a quantum mechanical state, represented by a wave function ψ, is as real as any other construct. Reality is, according to Margenau, an attribute of valid constructs and of those parts of "Nature" (immediate data) which are connected to valid constructs by laws of correspondence. There is nothing behind these constructs, no "*Ding an sich*," as in Kant's philosophy. Models are strictly forbidden: "Thou shalt not make unto thee any graven image."

This is, of course, the extreme standpoint of Dirac, which has numerous followers among the younger generation of theoretical physicists. But there is the more moderate school of Niels Bohr who tries to reconcile abstract theory with intuitive understanding by his principle of complementarity. It is obvious that Margenau rejects this, not as wrong but as superfluous for a superior mind. Yet I think that Bohr is perfectly right, because models are needed to find the right words for expressing a situation. That this is so, is again proved by Margenau's book itself. For, though he would obviously prefer to remain in the pure sphere of abstractions, he cannot avoid giving a few examples for indeterminacy in quantum mechanics; he apologizes for speaking of positions and velocities of electrons and such like model concepts and says that this is only to avoid clumsy language. Yet he gives not the slightest indication of correct, though clumsy, language. Naturally, because it does not exist.

Many other objections may be raised, for instance, against the author's contempt for the inductive method in science, and the treatment of causality. Though the book is full of good ideas, brilliant formulations, witty remarks, it is, from the standpoint of the physicist, carelessly written. The number of indefensible mistakes I have found is considerably large. To mention a few of them: When elasticity is discussed, six strain components are introduced as observables (p. 197) and it is said that the differential equations are of the first

order. However, it is well known that these six variables are not independent, but connected by three compatibility relations, and that by proper elimination the differential equations are of the second order in space and time. This is not a slip of the pen, for it is repeated in a table on p. 413.

In statistical mechanics, the methods of Boltzmann and of Gibbs are compared and the abstract character of the latter is stressed; but it is not said that it permits the treatment of systems of interacting particles, while Boltzmann's theory holds only for systems of free particles.

A popular presentation of quantum mechanics is so difficult that the numerous objectionable statements made in the corresponding chapters of the book ought to be pardoned.

I think that the imperfections mentioned are more than balanced by the attractions of the book, and I recommend it as a stimulating and entertaining introduction into the philosophical problems raised by modern physics.

Principles of Nuclear Chemistry, by Russell R. Williams, Jr., D. Van Nostrand Co., Inc., New York, 1950, 307 pages, $3.75. *Reviewed by Adolf F. Voigt, Institute for Atomic Research, Iowa State College.*

This book, a text in the chemistry associated with nuclear processes, presents its subject largely from a descriptive viewpoint. It avoids physics in order to emphasize the various chemical aspects of nuclear science. It would hardly give sufficient training in radiochemistry to prepare graduate students for research in the field, but it would be admirable as a text for college seniors. It reads easily and should find a market among scientists who want to keep up with new developments.

One of its unique chapters treats physical and chemical manifestations of nuclear mass. The effect of the isotopic mass on such diversified phenomena as atomic and molecular spectra, partition functions and their relation to equilibria, and reaction rates is considered quite briefly along with the application of these differences to isotope separation.

The author uses three chapters to discuss at some length such topics as the principles of radiochemical techniques, the purification and analysis of radioactive nuclides, the chemistry of the artificial elements, chemical reactions induced by nuclear change, the Szilard-Chalmers and similar processes, and radiation chemistry. The biological effects of radiation and health physics are mentioned briefly. The final chapter on applied nuclear chemistry mentions the uses of radioactivity in geology, enumerates a variety of chemical systems in which exchange has been studied, and presents a few applications of tracers in chemical research and analysis along with some of the principles of such research.

The appendices include a periodic table containing useful information about electronic binding energies and a nuclide chart which is already out of date. It does not seem economical to put an elaborate but obsolescent chart in a text which should remain useful for some time.

Criticism could be directed to a number of omissions in the presentation of the more traditional parts of the subject which occupies the other four chapters. For example, the author does not mention the newer types of accelerators or the use of magnetic spectrometers to determine particle energy or the use of coincidence counters to study decay schemes. Almost nothing is said about radiation dosage or its calculation. The index is not complete.

There are more than a few misstatements, probably careless ones. As an example, contrary to the book, neither Nd^{151} nor Sm^{151} is stable so that their

intermediate isobar, Pm^{151}, could be stable without breaking any rules. Also the field strength around a wire decreases inversely instead of logarithmically with the distance from the axis. Thorium is "rather abundant" on page 164 and "fairly rare" on page 193. Of proofing errors, the book has more than its share.

The author tries to break away completely from the prefix "radio-" to indicate nuclear instability and refers constantly to "unstable nuclides." While "radio-" may not be the best usage, it is accepted and does avoid possible confusion with the chemical use of the word "unstable." The use of "curie" as a general unit is deprecated in the book, but it has recently acquired official sanction and we should be able to use it without blushing.

The book also has, as study aids, sets of problems which do not require much thought, and supplementary reading lists which should be helpful to the student who wishes to look more deeply into the subject.

Radioactive Measurements with Nuclear Emulsions, by Herman Yagoda, John Wiley & Sons, Inc., New York, 1949, ix + 356 pages, $5. *Reviewed by Louis S. Osborne, Laboratory for Nuclear Science and Engineering, Massachusetts Institute of Technology.*

The sensitivity of photographic plates to radiation other than light in the visible spectrum has been known and used to detect X-rays and radioactivity for decades. In the past ten years, however, photographic plates have been developed that have small AgBr grains of high sensitivity in a microscopically thick gelatin emulsion. Thus the track of a particle with a single electron charge or more which has passed through the emulsion may be seen in the developed plate when sufficiently magnified. Examination of individual events allows the determination of such quantities as the energy and direction of each particle.

The initial chapters of this book take up the history, preparation, and developing techniques for these nuclear emulsions. The major part of the book is devoted to their use as detectors of radioactivity and, for the most part, as α-particle detectors. The author has compiled in detail the methods and results of experiments where the quantitative localization of a radioactive isotope in an aggregate of material is of importance.

In addition, the range of the α-particle, which is determined by its energy, frequently allows the specific identification of the parent isotope. Various chapters deal with the use of the technique in several fields. The author has described many experiments localizing various heavy elements in animal tissues, minerals, crystals, colloids, and chemical precipitates. From analysis of precipitates, specific co-precipitation processes for the heavy elements are presented.

The detection of lighter elements is not amenable to the above technique but can be ascertained by β-radioactivity where such exists. When this book was published, the development of emulsions which would show the track of a single charged particle with a speed comparable to that of light had not yet been attained. Therefore, the techniques discussed for β-radioactivity and γ-rays concern only its localization with ordinary high-speed or X-ray films. The use of this process is discussed again in relation to its applications to biology, metallurgy, and crystallography for the measurement of inclusions of β-radioactive material.

The last chapter is an exposition of the use of these emulsions in nuclear physics. Included in this chapter is an unfortunately short description of the interactions of charged particles with the nuclear emulsion to explain range

and track density (developed silver grains per unit length) in terms of the mass, charge, and energy of the particle (which permit identification and energy measurement of a particle). This chapter includes a discussion of nuclear emulsions for the detection and measurement of nuclear interactions and particles. Several illustrations are given from the study of cosmic rays and high-energy particle accelerators.

A book written during the rapid development of a field will be found in time to suffer from omissions; though the lack of such a book leaves the beginning student forced to accumulate material from a multitude of sources.

The study of the behavior of particles in the emulsion which is fundamental to this technique could have been handled more fully; thus, the effect of multiple scattering, a quantitative measurement to measure particle energy, is neglected completely. The book suffers from the organization of its material so that the techniques of handling nuclear emulsions are intermixed with specific experimental uses.

The greatest value of the book, besides the compilation of experimental results, is the exposition of detailed laboratory techniques and suggestions necessary to the beginner, and the great variety and breadth of their applications in many fields with which the author is acquainted.

BOOKS RECEIVED

Introductory Nuclear Physics, by David Halliday, John Wiley & Sons, Inc., New York, 1950, ix + 558 pages, $6.50.

Industrial and Safety Problems of Nuclear Technology, edited by Morris H. Shamos and Sidney G. Roth, Harper & Brothers, New York, 1950, xii + 368 pages, $4.

Economic Aspects of Atomic Power, by Sam H. Schurr and Jacob Marschak, Princeton University Press, Princeton, N. J., 1950, xxvi + 289 pages and 2 pull-out charts, $6.

OTHER LITERATURE

Atomic Energy Commission Document Price List 17. A revised and cumulated listing of documents in Price Lists 13–16 inclusive, together with titles of documents made available since the issuance of List 16 in June, 1950. Purchase of documents listed must be made from the Office of Technical Services, Dept. of Commerce, Washington 25, D. C. *Copy of price list available without cost from U. S. Atomic Energy Commission, Technical Information Service, Oak Ridge, Tenn.*

October 1950 Bibliography of Technical Reports. Describes a survey by Erik G. Linden of the Fort Monmouth Signal Corps Engineering Laboratories in which researches are detailed on a wide range of phosphors in radioactive paints, in scintillation counters, in fluorescent dyes, etc. *Available from the Office of Technical Services, Washington 25, D. C., $0.50.*

Annual Report of the National Bureau of Standards for 1949 (NBS Miscellaneous Publication 198). A 101-page, illustrated booklet containing a summary of the scientific investigations carried on at NBS during the fiscal year 1949. *Available from the Superintendent of Documents, U. S. Govt. Printing Office, Washington 25, D. C., $0.75.*

A Survey of the Work of Dr. Eugene Ryschkewitsch (PB 97646). Principal sections of this 110-page report deal largely with the ceramics researches conducted by an authority on German developments in high-temperature physical and technical chemistry. *Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C., $2.75.*

CROSS SECTIONS

Hood and Grasping Device for Work with Radioisotopes

By A. Garen and C. Hlad
Department of Biophysics, University of Colorado Medical Center, Denver, and Radioisotope Unit, Veterans Administration Hospital, Fort Logan, Colorado

The high cost of commercially available radioisotope equipment, usually designed for chemical work with very high levels of activity, imposes a hardship on biological laboratories interested only in tracer and therapeutic procedures at lower levels of activity. An easily constructed hood offering safety, flexibility and economy has been so satisfactory for a variety of biological and medical applications of radioisotope techniques as to warrant brief description.

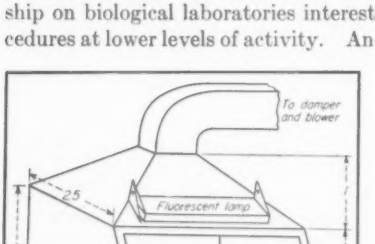


FIG. 1. Stainless-steel hood with Plexiglas windows and movable lower panel. Clamp used to hold lower panel open against upper one is not shown

The hood* shown in Fig. 1 is constructed of 22-gauge stainless steel, with two ¼-in. Plexiglas panels. The lower panel can be raised and locked into place over the upper one by means of a simple friction clamp. Illumination is supplied through a Plexiglas window by two 20-watt fluorescent lamps mounted on the outside with pivots which provide easy access for tube replacement. Gas, air, and vacuum ports permit in-

* Developed in connection with a research program aided by a grant from the Division of Biology and Medicine of the Atomic Energy Commission, and administered under contract with the Office of Naval Research.

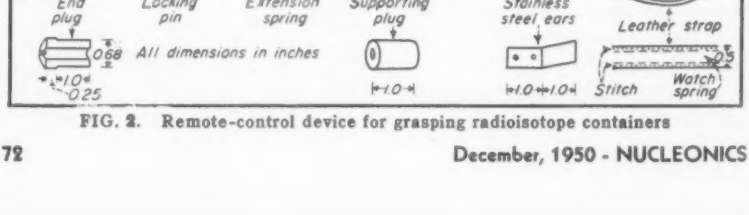
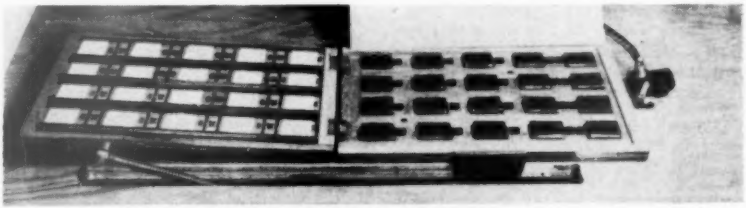


FIG. 2. Remote-control device for grasping radioisotope containers

troduction of these facilities by means of rubber tubing connections on each side of the steel wall. Each hood is supplied with its own damper for airflow regulation, and joins a common duct which extends up along the outside wall of the building to a point 10 ft beyond the roof. A single blower with capacity of 4,000 ft³/min on this common duct provides an inward air flow of 100 ft/min through the opening of three such hoods and precludes backward flow which may occur if separate blowers are provided to each hood and then joined to a common exhaust duct.

The use of a metal mirror mounted in the rear of the hood and removable barricades made of lead bricks (or less expensive interlocking cylindrical rings†) makes possible routine handling of as much as 150 mc of I^{131} with no significant exposure of the operator to radiation. Three such hoods can be constructed and installed at a total cost of $1,000, which includes the blower and exhaust duct.‡

A light-weight, (aluminum, Duralumin construction) remote-control device (Fig. 2) has been found particularly convenient for grasping samples with high activity. A leather strap, under controlled tension provided by a steel spring (8 lb, 8-in. extension spring) grips the vessel securely. The position of the handle controls the spring tension. It can be locked in any of several settings by pins fastened to the central rod which fit into a notch in the end-plug. With machine shop facilities available, the device can be constructed in a few hours.† The parts cost less than $5.00.



Beta Calibration Rack Using Uranium Oxide§

By W. C. Herman
Brookhaven National Laboratory, Upton, New York

To obtain valid indications of exposure to beta radiation, the film badges used in personnel monitoring must be calibrated with a known source. The source used here for beta calibration of DuPont 552 dental film packets is uranium oxide in copper planchets. "Q" dope and uranium oxide powder were mixed to a heavy paste consistency and then placed in the copper planchet. The surface was smoothed off level with the sides of the planchet and a fine mixture of "Q" dope and benzene solvent was sprayed over the top to prevent any particles from being rubbed off. The dosage rate as determined by film density compared to films exposed to uranium metal has been calculated as 224 mrep/hr.

Twenty planchets are set into a baseboard of ⅝-in. plywood 9¼ × 12¾ in. The bottom of each planchet is cush-

† Can be furnished by Technical Equipment Corporation, Denver, Colorado.
‡ Frank Scherer and Son, Sheet Metal Co., Denver, Colo. can supply hoods of this design.
§ Research carried out under the auspices of the AEC.

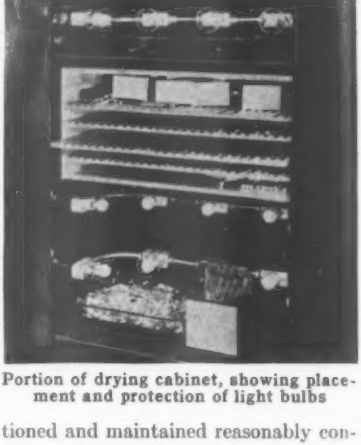
ioned with sponge rubber, insuring a more uniform pressure when the film packet and planchet are in contact. Twenty film packets separated by cardboard spacers are placed between copper tracks on a plywood board of the same dimensions that is hinged to the board containing the planchets. To expose the films the two halves are sandwiched together.

The two halves are held together by a catch which is released at the end of a specified time period by the action of a solonoid. This time of exposure is preset on two timers, one used for hours and the other for minutes and seconds. The half holding the film is then opened by spring tension. A microswitch deactivates the solonoid.

Inexpensive Drying Cabinet for Instrument Storage*

By C. F. Stearns
Brookhaven National Laboratory
Upton, New York

A need was felt for a drying cabinet to store instruments sensitive to moisture, although the room in which the instruments are located is air conditioned and maintained reasonably constant at 75° F, 50% relative humidity.

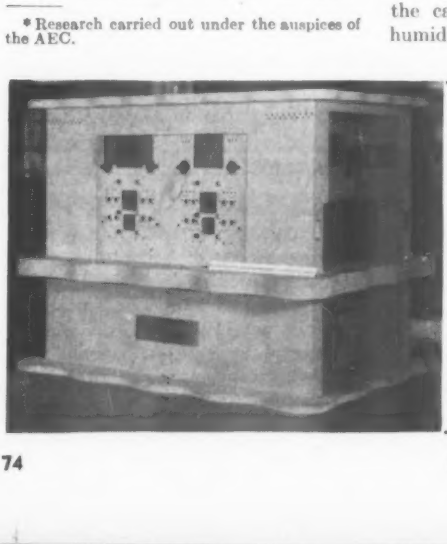


Portion of drying cabinet, showing placement and protection of light bulbs

Five banks of five 15-watt, 110-volt bulbs were mounted in an inexpensive stationary-type metal cabinet whose dimensions are 76 × 35 × 18 in. Switch and fuse box were mounted on the outside.

Adequate convection of air to prevent overheating is maintained through the cracks between the shelves and sides as well as around the doors. The average temperature and humidity of the cabinet is 105° F, 20% relative humidity except when the doors are

* Research carried out under the auspices of the AEC.



SCALE MODEL, 1/12 size, of isotope research cells under construction at Oak Ridge National Laboratory, shows lead doors, openings for high-density liquid-filled windows and periscope in sides. Exhaust duct and liquid waste disposal tubes run below cells. Main body of structure is made of high density concrete to shield high activities. Entire interior is lined with stainless steel

opened. The effect of the doors being momentarily opened is quickly overcome.

This cabinet has been used mainly for personnel monitoring equipment. Pocket chambers periodically dried overnight have given good service even underconditions of high humidity.

TECHNICAL BRIEFS

• **Speed of light** was determined with new accuracy recently as 186,280.0 miles/sec by Stanford University physicists. Microwave resonance techniques were used. Similar, confirming results have been obtained in England and Sweden.

• **Gamma-ray source** of approximately 80 curies for irradiation purposes has been completed at Brookhaven National Laboratory. The source is an 11-in. square horizontal plane and gives a fairly uniform radiation level in excess of 900 r/hr at a distance of 1 ft. It was constructed for Brookhaven's medical division.

• **Metallic filters** with 40–50 % porosity that will retain particles as small as 0.2 micron have been fabricated by W. W. Wellborn and J. R. Armstrong of Los Alamos Scientific Laboratory. Powder metallurgy techniques were used to form chemically produced spongy platinum, gold, silver and nickel into filter disks with yield strengths from 4,000 to 10,000 lb/in^2.

• **Phenolic resins** outperform stainless steels in withstanding corrosive acids, according to R. B. Seymour, technical director of Atlas Mineral Products Co., Mertztown, Pa.

PATENTS RELEASED

The Atomic Energy Commission has released 17 more patents for nonexclusive, royalty-free use. Copies of the patents listed can be obtained from the U. S. Patent Office, Washington, D. C. For licenses, apply to the Chief, Patent Branch, Office of the General Council, U. S. Atomic Energy Commission, Washington, D. C.

Valve (2,521,891), J. W. Beams. For centrifuge or other rotating device, this valve is not affected by speed of rotation.

Low Inductance Resistor (2,521,894), R. J. S. Brown.

Method of Purifying Inert Gases (2,521,-937), A. S. Newton. Metallic uranium used at controlled temperatures to remove hydrogen, other impurities.

Resistance Capacitance Network (2,523,-856) W. R. Baker. Variable noninductive filter with capacitance distributed evenly is designed for oscillator use.

Extraction Process for Cerium (2,523, 892), J. C. Warf. Extracted in tetravalent form from salted acid solution by means of nitromethane.

Neutron Velocity Secector (2,524,379), E. Fermi. Rotating shutter is used with photoelectric control of detector.

Production of Uranium Triiodide (2,-524,384), J. A. Holmes.

Saturable Core Triggered Gap (2,524,-388), Q. A. Kerns. Arc gap unit is capable of passing heavy current.

Scaling Circuit (2,524,692), W. H. Bradley. Circuit will operate on input pulses of positive polarity; pulse-height selector is direct-coupled to first scaling stage.

Thermal Flowmeters (2,525,197), J. W. Beams, L. B. Snoddy, L. G. Hoxton. Gas flow mass rate is measured accurately at low pressures and low rates of flow.

Processes for Production of Mesitylene (2,526,213), W. M. Ewalt.

Method of Forming Uranium Carbon Alloys (2,526,805), J. H. Carter, A. H. Daane. Uranium and carbon powders are heated while in contact.

Fluid Selecting Apparatus (2,526,825), A. O. C. Nier, R. B. Thorness, G. H. Goertzel.

Dehydration of Alkali-Metal Acid Fluorides (2,527,320), R. C. McHarness, A. F. Benning.

Pump (2,528,415), H. A. Boorse, G. F. Boeker. Electromagnetic operation used to pump corrosive, poisonous or noxious fluids.

Stuffing Box and Expansion Joint (2,528,436), M. E. Johnson. Designed for retort with a rotating shaft.

Coating Process (2,528,454), H. I. Schlesinger, G. W. Schaeffer. Used for depositing boron in the amorphous state as a compact, nonporous coating.

NUCLEONIC EVENTS

REVISION OF DECLASSIFICATION GUIDE ANNOUNCED BY U. S., U. K., CANADA; LOW-POWER REACTORS "OPENED UP"

Revision of the Declassification Guide to permit publication of information related to specific low-power nuclear reactors was announced on November 24 by the governments of the United States, the United Kingdom and Canada. Six reactors, four of which are in this country, are affected by the new Guide.

Technical information declassifiable under the new Guide must be reviewed prior to publication, in accordance with the declassification procedures in effect in each of the three nations. The information now releasable is said to describe what must be known in order to assemble and operate a low-power research reactor. However, before such a reactor can be built by a private institution, permission of the government in question to use the necessary fissionable materials is required.

It is expected that the newly declassifiable information will be useful largely in advanced courses in reactor physics. It will now be possible for instructors to use specific data obtained from actual experiments, instead of discussing reactor technology in general and theoretical terms.

The research reactors on which design and operation information will be considered for declassification are:

1. the world's first nuclear reactor, constructed from uranium and graphite under the West Stands of the University of Chicago's Stagg Field in 1942 and subsequently dismantled,

2. a modified version of the West Stands reactor, located at the Palos Park site of the Argonne National Laboratory near Chicago,

3. a uranium and heavy water reactor located at the Dupage County site of the Argonne National Laboratory,

4. a homogenous enriched uranium, light-water reactor located at Los Alamos Scientific Laboratory, Los Alamos, New Mexico,

5. a uranium and graphite reactor ("Gleep") located at Harwell, England, and

6. a uranium and heavy-water reactor ("Zeep") located at Chalk River, Ontario.

The revision of the Declassification Guide is an outgrowth of the fourth international declassification conference held February 9–12, 1950, at Harwell, England.

Of most general interest among data to be released is the fact that low-energy, thermal neutrons are captured in appreciable quantities by uranium-235 without causing fission. It would be inferred from earlier studies of fission, that almost all thermal neutrons captured by fissionable U^{235} would result in fission. However, a significant fraction of all thermal neutrons colliding with U^{235} are captured to form U^{236}. Engineers designing uranium reactors must keep this fact in mind since these captured neutrons are not available to continue the chain reaction.

A more precise value for the number of neutrons produced on fission of U^{235} by thermal neutrons will also be re-

leased. This number, hitherto has been quoted as between 2 or 3.

Other data to be declassified include a description of the energy distribution of the neutrons released instantaneously when U^{235} is fissioned by thermal neutrons, and a formula showing how "lumping" the natural uranium in low power piles affects the capture of neutrons during their slowing-down process.

Description of U. S. Reactors to be Declassified

1. Argonne uranium-graphite reactor. Constructed at the University of Chicago, this reactor, the first ever built, operated at a maximum power level of 200 watts. It was later transferred to the Argonne site.

Construction—The external dimensions of the reactor are: 30 ft wide, 32 ft long, and 21 ft high. The shield consists of 5 ft of concrete. For the reactor itself, the basic construction unit was a graphite block, 4⅛ in. by 4⅛ in. by about 16½ in.

Cylindrical recesses spaced 8¼ in. from center to center were cut in the blocks. Uranium cylinders 2¼ in. in diameter and weighing about six pounds were inserted into these recesses.

In order to reflect stray neutrons back into the reactor core, the uranium-bearing material was surrounded on all sides by at least 12 in. of dead graphite. The reactor became chain-reacting or critical at the 50th layer. An additional four layers of dead graphite were then added above the 50th layer to complete the reflector across the top of the reactor.

Materials used—Because of the relatively small amount of uranium metal available at the time of the construction of the reactor, a large number of the recesses were filled with uranium oxide. To use the available metal in the most efficient manner, it was placed in the center of the reactor and was surrounded with the uranium oxide lumps. Accordingly, live graphite pieces containing about ten tons of metal lumps were piled in layers to form a central lattice mass about 13 ft wide, 10 ft deep and 10 ft high, which was positioned between the 16th and 48th layers of the reactor.

The reactor contains about 3,200 uranium metal lumps weighing about 10 tons. About 14,500 uranium oxide lumps were used, bringing the total amount of uranium in the reactor to about 50 tons. The weight of graphite in the reactor is about 472 tons and the total weight of the reactor including the core, reflector, shield, and lead top is in excess of 1,400 tons.

2. Argonne heavy-water reactor. Measurements performed on heavy water with the use of the graphite-moderated pile during the summer of 1943 proved the feasibility of a heavy-water reactor and had produced sufficient information to permit its construction.

Construction of a building was begun in September, 1943, and on May 15, 1944, the heavy-water reactor was operated at low power. Thus, it became the world's first heavy-water nuclear pile.

Description—In comparison with graphite-moderated reactors, the heavy-water reactor is quite small. It consists of an aluminum tank, six feet in diameter and eight feet-ten inches high, which is filled with approximately six and a half tons of heavy water (amount contained in 32,000 tons of ordinary water) and into which are suspended

ABOUT THE COVER

The nuclear reactor in the sketch on the cover is described in the article starting on page 5.

120 uranium metal rods, 1.1 inches in diameter and six feet long. The uranium rods, whose total weight is nearly three tons, are arranged to form a square lattice with the distance from center to center being 5⅜ inches. Heavy water, which is present in ordinary water as one part in 5,000 serves as the moderator. The heavy water serves not only as a moderator, but as a cooling agent as well.

The reactor tank rests on a two-foot layer of graphite blocks supported by the concrete pile foundation. The graphite reflects the neutrons to the reactor core. In addition to this neutron reflector on the bottom, the sides are provided with a reflector of equal thickness.

A four-inch shield of lead-cadmium alloy surrounds the reflector and fits snugly against a thick concrete shield which encases the entire reactor. The lead-cadmium alloy protects the concrete from exposure to neutron and gamma radiation. A one-foot shield of lead bricks is placed on top of the graphite reflector and is continued over the top plate of the reactor tank. Between the bottom of the lead cover and the top plate of the reactor tank is a thin layer of cadmium metal.

The space between the heavy water and the cover of the tank is filled with helium. This inert gas replaces ordinary air which would normally be present and which must be kept out of the system. Moisture, in the air, would be condensed inside the reactor tank and would dilute the rare and expensive heavy water. There is another objection to the use of air. Inasmuch as nitrogen makes up about four-fifths of the atmosphere, radiation bombardment of air would result in the formation of nitric acid.

Two blower pumps circulate the helium through a cooler and through a catalyst chamber. These pumps, one of which is normally a stand-by pump, circulate the helium gas and dissociated heavy water. Under neutron bombardment heavy-water molecules break apart to form oxygen and heavy hydrogen and these gases are recombined in the catalytic chamber and returned to the reactor tank.

Concrete biological shield—The reactor core is surrounded with a biological shield which is in the form of an approximately octagonal concrete prism thirteen feet high and having walls eight feet thick. The top of the reactor is shielded with a four-foot layer of blocks of wood and steel weighing eighty tons.

Neutron column—The thermal neutron column consists of a stack of ordinary graphite blocks five feet square and seven feet-eight inches long extending back to the neutron reflector. The end extending through the concrete shield is covered with a cadmium curtain and a two-foot lead and iron shield in which an eight-inch square opening is provided.

Central experimental thimble—In addition to eleven openings in the sides of the reactor, an opening known as the central experimental thimble extends from the top of the reactor into the heavy water. This opening has been made by extending a four-inch aluminum pipe from the center of the top shield, through the tank lid, and down to within a foot of the aluminum tubes through which various samples may be lowered into the center of the reactor for exposure to fast and slow neutrons. Thirty-two irradiations may be performed simultaneously by the use of this facility.

Control system—The Argonne heavy water reactor is equipped with two control rods, two safety rods, and three shim rods. All contain cadmium metal so that they will absorb neutrons and stop the chain reaction.

The safety and control rods are each formed of a 3½-inch tubular sandwich

of $\frac{1}{32}$-inch cadmium placed between two aluminum tubes. These rods are hinged to the bottom side of the cover of the heavy-water tank. When they are in the "in" position (reactor would not be operating), they are hanging about 30 degrees from a vertical position. When the rods are in the "out" position, they are suspended in an almost horizontal position above the water in the tank. These rods move through a 60 degree arc.

The shim rods, sometimes called auxiliary control rods, are contained in aluminum tubes and are mounted inside the tank in a vertical position with one end of the rods penetrating through the top of the reactor tank.

Cooling system. The heavy water is pumped from the top of the reactor, passed through a heat exchanger located in the adjacent pump room, and fed back into the reactor tank through an opening at the bottom of the tank. In this way, 300 kilowatts of heat are removed from the reactor. The heavy water flow rate is 200 gallons per minute.

In normal operation, the average temperature of the heavy water flowing from the tank to the heat exchanger is 95° F while the heavy water being re-introduced into the reactor is, on the average, about seven or eight degrees cooler.

3. Los Alamos water boiler. Basically, the water boiler, as developed up to January, 1950, consisted of a container filled with an enriched uranyl solution surrounded by a neutron reflector and necessary radiation shielding, with the necessary control rods to regulate the power level and a cooling system to carry off heat generated by the reaction.

Low-power reactor—The original water boiler design for a low-power reactor (LOPO) was completed in November, 1943. The system became critical in May, 1944, with 1.2 pounds of U^{235}. The highest power at which LOPO was run during its several months existence was about 50 milliwatts, which raised the temperature to about 94° F.

High-power reactor—HYPO went critical in December, 1944, with about 1.8 pounds of U^{235}, although the normal loading contains about 1.9 pounds of U^{235}. Except for minor design changes, HYPO, as originally constructed, has operated successfully for several years.

The Los Alamos water boiler has been used primarily for physical experiments requiring a concentrated neutron source. It is the smallest and most economical type of chain reactor so far built. The peak power of HYPO was about 6 kilowatts, representing a neutron flux of about 3×10^{11} n/cm²/sec at the center of the reactor.

The heart of the reactor consists of a one-foot spherical stainless steel container filled with a uranyl nitrate solution in water. (See photograh on page 10.) The U in the uranyl salt contains about 1 part of fissionable U^{235} to 6 parts of non-fissionable U^{238}.

Surrounding the container is a reflector, or tamper, consisting of an inner core of beryllium oxide supplemented by a shell of graphite. The reactor and tamper occupy a cube about five feet on a side. The shield around the entire assembly consists of 4 inches of lead,

REPRINTS available of "Lab Equipment Guide"

A limited number of reprints of the special section published in the November NUCLEONICS devoted to a "Guide for Selection of Equipment for Radioactivity Laboratories" and "Buyers' Guide" are available and can be obtained by sending $1 for each copy desired to: Editorial Department, NUCLEONICS, 330 West 42d Street, New York 18, New York.

$\frac{1}{32}$-inch of cadmium, and 5 feet of poured concrete.

At the front or working face of the reactor a square tunnel pierces the shield. This tunnel was plugged with graphite to form a graphite thermal column and a number of ports for experimental irradiations were placed in the column and the tamper. A one-inch tube also extends through the shield, tamper and through the reactor sphere itself. It permits materials to be irradiated at the highest neutron flux level.

Because of its low power, LOPO required no cooling system. In HYPO, however, a six-turn cooling coil of $\frac{1}{2}$-inch tubing and having an effective length of 157 inches is wound in the form of a helix inside the sphere. About 50 gallons of water per hour is pumped through the cooling system, which is sufficient to permit year-round operation at six kilowatts.

When operating, the water in the fuel solution is decomposed by the highly ionized fission products forming about one-half cubic foot of hydrogen and oxygen gas per hour. Since this chemical mixture is extremely explosive and also since highly radioactive gases are produced in fission, some means of diluting and flushing out these gases was required. This was accomplished by means of a double inlet-outlet tube welded to the top of the sphere. Air is pumped through the inner $\frac{1}{4}$-inch tube and is exhausted through the outer $\frac{3}{4}$-inch tube. The inner tube may be raised or lowered so that it acts as an indicator of the solution level. Also by leading the gas from the outlet tube through test equipment, rapid analysis of the boiler gas may be made.

Copper-constantin thermocouples for measuring temperatures are placed in a tube extending into the center of the sphere and are also connected to the water inlet and outlet tubes.

HYPO is controlled by means of a cadmium shim rod, two cadmium control rods, and a cadmium safety rod. The latter always remains out during operation, since it is used only to stop the chain reaction in case the intensity should get too high. For additional safety, the two control rods are designed with a release mechanism so that they can stop as well as control the reaction. If both control rods and the safety rod are dropped at the same time, the neutron intensity falls 85 percent within one second.

Under normal operating conditions the water boiler is self-regulating due to the temperature effect. As the temperature increases the volume of the solution expands and the reactivity per unit volume declines. This automatically slows down the reaction so that under normal conditions it is impossible for the reactor to get out of control. If the control rods are pulled out too rapidly, however, the heat release could possibly be non-uniform through the solution. For very short times, say $\frac{1}{10}$ second or so, local hot spots might arise in which the solution would vaporize before the increased temperature had time to control the activity. In such cases the control rods would drop automatically to stop the reaction before serious damage to the reactor could occur.

GENERAL ELECTRIC OFFERS RESEARCH GRANTS

Applications for research grants are now being accepted under the $1,000,000 General Electric Education Fund for the scholastic year 1951–52.

Under the program, now in its 27th consecutive year, aid in grants up to $1,500 annually will be awarded to college graduates who wish to continue individual study and research in scientific and industrial fields.

Applications for the fellowships must be filed by January 1, 1951, and mailed

to the Secretary, General Electric Company Education Fund, Schenectady, New York.

POWELL GETS NOBEL PRIZE FOR MESON RESEARCH

The 1950 Nobel Prize for physics was awarded last month to Cecil Frank Powell for "his developments of the photographic methods of studying nuclear processes." The research for which he won the award, worth $31,718, led to confirmation of the existence of the meson, the subatomic particle postulated by Yukawa in 1934. Photographic plates left by Powell in boxes on a peak in the Swiss Alps yielded the first traces of the meson.

Dr. Powell has been physics professor at Bristol University for twenty-two years and is the thirteenth Britain to win the Nobel Prize in physics. His wife, Isobel, assists him with his research.

SCIENCE RESEARCH AWARDS MADE BY OAK RIDGE INSTITUTE

Thirteen scientists from four of the sponsoring institutions of the Oak Ridge Institute of Nuclear Studies shared in the $1,700 in Science Research Awards given recently by the Institute to honor outstanding research papers published by Southern scientists in 1949.

O. G. Harrold of the University of Tennessee received a $500 cash award for his paper on *Euclidean Domains with Uniformly Abelian Local Fundamental Groups.*

Two papers from the University of Florida were combined to be given one award of $500. Henry C. Harris was the author of one paper (*The Effect on the Growth of Peanuts of Nutrient Deficiencies in the Root and the Pegging Zone*) and also one of the three authors of the second paper (*Absorption of Radioactive Calcium by the Peanut Fruit*). The other authors were Roger W. Bledsoe and Cyril L. Comar.

Four papers from the University of Tennessee on the subject of *The Catalytic Hydrogenation of the Benzene Nucleus* were combined to be given one award of $500. The authors of the four papers included Hilton A. Smith, Comer D. Schacklett, Clark M. Welch, the late David M. Alderman, James A. Stanfield, Henry T. Meriwether, and John F. Fuzek.

Two other awards of $100 each were made to Frank M. Hull of the University of Mississippi for his paper on *The Morphology and Inter-relationship of the Genera of Syrphid Flies, Recent and Fossil*, and to Charles M. Wilson, Jr., of Vanderbilt University, for his paper entitled *Pre-Chattanooga Stratigraphy in Central Tennessee.*

A total of 131 papers were entered in the contest, and the awards were announced at the recent Southwide Chemical Conference held in Atlanta, Ga.

Because of the growth of the main ORINS programs and the consequent demands on funds contributed by its sponsoring institutions, the Board of Directors has decided not to renew these awards for the coming year.

AEC ASSIGNED NPA "DO" PRIORITY RATINGS

Under authority granted to the Atomic Energy Commission by the National Production Authority (NU, Nov. '50, p. 55), the Commission and its contractors have been assigned the following "DO" priority symbols: DO-40 for operations; DO-41 for construction, except construction equipment; DO-42 for construction equipment; DO-43 for prime and subcontractors' privately owned facilities; and DO-44 for other privately owned facilities.

In general, symbols DO-40 through 42 are being used on contracts and purchase orders for items purchased by or

for the account of the AEC. The symbols DO-43 and 44 are being used on contracts and purchase orders for construction material and capital equipment purchased by private concerns for their own account but for AEC work.

IN BRIEF

➢The American Cyanamid Company, New York, will operate under AEC contract the chemical processing plant being built at the reactor testing station in Arco, Idaho.

➢*France recently observed the fiftieth anniversary of the discovery of radium by Pierre and Marie Curie by dedicating a tablet on the house in the suburb of Sceaux where they resided from 1907–1922.*

➢Gabriel M. Giannini has announced that because of the disappearance of Bruno Pontecorvo, Italian-born British scientist, his firm has renounced its interest in the $10,000,000 suit it had filed against the U. S. Government for use of certain basic processes in the production of atomic explosives on which it held patent rights (NU, Oct, '50, p. 96). Pontecorvo was one of seven Italian researchers who were awarded an American patent on the process in 1940 and had assigned all rights to Giannini.

➢*A 10-Mev linear accelerator is nearing completion and will soon be installed at the Hammersmith Hospital in London. Built to produce high-energy X-rays for therapy purposes, the machine was designed and constructed by the Metropolitan-Vickers Electrical Co., Ltd., of Manchester, which is also constructing three of the five 4-Mev linear accelerators that the British Ministry of Health has ordered for clinical use in selected hospitals.*

➢The AEC has issued an export license to the High Voltage Engineering Corporation, Cambridge, Mass., covering the shipment of a 2-Mev Van de Graaff positive ion electrostatic accelerator to the National Autonomous University of Mexico.

➢*Representatives of the AEC and the Government of the United Kingdom recently held discussions in Johannesburg, South Africa, with Union authorities on the production of uranium from gold-bearing ores. Sole rights to uranium deposits in the Union of South Africa are held by the Union government under legislation passed two years ago.*

➢Harwell authorities have expressed disappointment over the small number of British industrial organizations which are seeking to make use of radioisotopes. According to *The Chemical Age*, 20 firms ordered isotope shipments from Harwell for industrial use in May, 27 in June, 47 in July, and 53 in August. Total shipments in August numbered 429 and included mainly 785 mc of phosphorus, 254 mc of iodine, and a small amount of carbon and cobalt.

➢*The first board of directors of the new National Science Foundation was named last month by President Truman. The appointees comprise twenty-four of the nation's leading scientists, civic leaders and business men. The chairman of the board will be named by the group itself at its first meeting.*

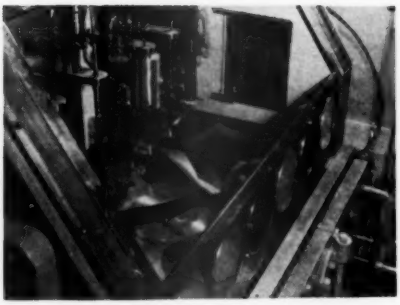
NUCLEAR NEWSMAKERS

Lauriston S. Taylor this summer delivered the Sylvanus Thompson Memorial Lecture before the meeting of the British Institute of Radiology. Chief of the radiation physics laboratory of the National Bureau of Standards, Dr. Taylor is the first American scientist to receive this honor since the lectures were begun in 1916.

Newton Underwood, Raymond Murray, Lee W. Gildart, Albert W. Blackstock, Leon H. Robinson, Jr., and V. E.

(Continued on page 104)

1 Glove box provides contamination control by isolating activity, but shielding is adequate only for alphas and low-energy betas

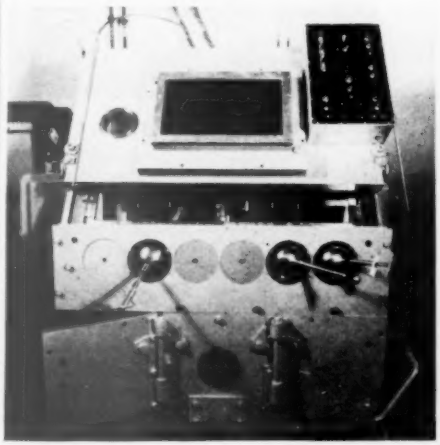


2 Added shielding—three inches of steel shown—protects operator for gamma work. Gloves are replaced by ports with sleeves

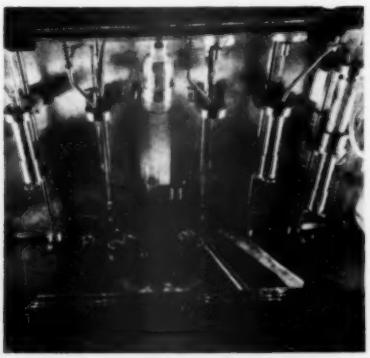
3 Manipulator in ball-and-socket joint allows freedom of action

Adapting Glove Boxes to Gamma Work

(Photos courtesy of J. F. Gifford, General Electric Co., Richland, Wash.)



4 "Junior Cave," based on glove-box design, has 1,000-pound sloping front which cranks down into position. Note the viewing window



5 Window with 22 layers of lead glass in tank of monochlorobenzene, is 5½ inches thick. Visibility is almost undistorted

PRODUCTS and MATERIALS

MICA-WINDOW G-M TUBE

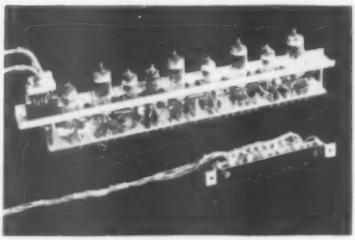
Able Scientific Glass Apparatus Co., 6859 S. Anthony Ave., Chicago 37, Ill. Available with an end window thickness of 1.5–2.0 or 2.1–3.5 mg/cm², the model M-22 G-M tube has a plateau length of 200 volts. Plateau slope is 3% per 100 volts. The tube is filled with self-quenching gas and has an operating life of 10^9 counts. The mica window is fused directly to the glass envelope of the tube. Depressions in the envelope 11 mm from the window and 120 degrees apart facilitate geometry reproduction. The tube is available for use at 1,150–1,350 or 850 volts.

SURVEY METER

Nuclear Instrument & Chemical Corp., 229 W. Erie St., Chicago 10, Ill. The model 2581 is an improved version of the wartime "Zeuto" survey meter. Battery powered, it is a nondiscriminating rate meter for the detection of alpha, beta, and gamma radiation.

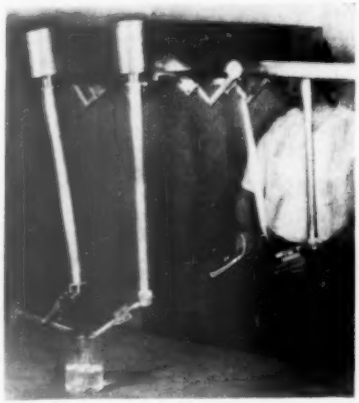
I^{131}-TAGGED ALBUMINS

Department of Special Research, Abbott Laboratories, North Chicago, Ill. A sterile solution of iodine-tagged human serum albumin is available in appropriate activities for determination of blood volumes. A maximum of 50 μc is said to suffice for a single determination, and subsequent doses may be used in cases of prolonged bleeding. Other blood fractions, including the gamma globulins, are being prepared on order for immunology research.



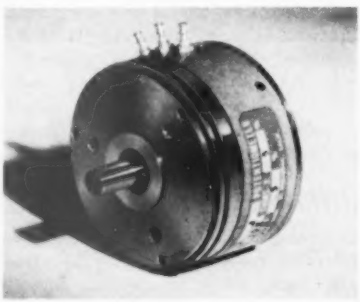
DECIMAL COUNTING UNITS

Berkeley Scientific Co., 23rd and Wright Sts., Richmond, Calif. Two high-speed counting units are designed for scale-of-10 operation and provide direct reading from a remote indicator. The model 706 has a maximum counting rate of 200,000 pulses/sec with 2.5 μsec resolution of pulse pairs, and requires a negative pulse input of 50–150 volts peak amplitude and 0.2 μsec duration. The model 707 has a maximum counting rate of 1,000,000 pulses/sec with 0.8 μsec resolution, and requires a negative pulse input of 120–180 volts and 0.1 μsec duration. Both models require input pulse rise times of less than 0.1 μsec.



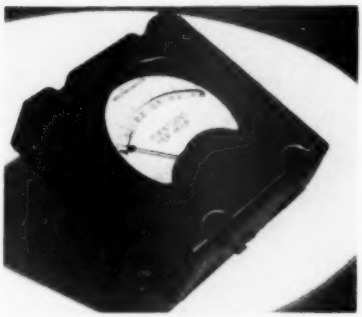
MASTER-SLAVE MANIPULATOR

Central Research Laboratories, Inc., Red Wing, Minn. The CRL model 1 remote-control manipulator is claimed to be able to execute virtually any manipulation possible with the human hand. Motion of the operator's hands is reproduced in a one-to-one ratio by the manipulating claws. The standard model is designed to operate over a barrier 26 in. high. It will manipulate a maximum of 5 lb on each arm anywhere within a volume approximately 4 ft wide, 2 ft deep, and 2 ft high.



POTENTIOMETER

Helipot Corp., South Pasadena, Calif. The model J single-turn potentiometer was designed for use in servomechanisms and computers. Resistances ranging from 50 to 50,000 ohms are available with a resistance tolerance of $\pm 5\%$ and linearity tolerance of $\pm 0.5\%$. Power rating is 5 watts. Lower tolerances can also be supplied. The potentiometer shaft is ball-bearing mounted, and starting torque is 0.75 ± 0.25 in.-ounces. As many as 20 taps can be made on the resistance element. The unit, which weighs 4 ounces, is furnished with either a three-screw or bushing mounting.



SCALE-CHANGING METER

Westinghouse Electric Corp., Meter Division, Newark, N. J. Only one of four scales is visible at once in the Universal Roentgen Meter, a microammeter calibrated for radiation measurement. Scale shifting is controlled mechanically, and provision is made for connecting the control to the same knob that controls the amplification setting in a radiation-detecting instrument. The meter is supplied with full-scale values of 20 and 50 μa and an internal resistance of 1,500 ohms. A linear scale is used on all models.

RECTIFIER CARTRIDGE

International Rectifier Corp., 6809 S. Victoria Ave., Los Angeles 43, Calif. Available in either phenolic, glass or hermatically sealed assemblies, these

high-voltage selenium rectifier cartridges have a voltage drop of 25 volts at rated load. The cartridge is rated at 440 volts d-c and 10 ma, with a peak current rating of 120 ma and a peak inverse rating of 1,500 volts. Weight is ½ ounce, and dimensions are $^{9}/_{16}$ × $1^{5}/_{8}$ in. Cartridges with other ratings are also available.

FLOW COUNTER

Tracerlab, Inc., 130 High St., Boston 10, Mass. The model SC-16 windowless flow counter is essentially a shielded counter tube into which solid samples are inserted directly. A constant gas flow through the counter prevents air contamination. A three-position sample turntable permits loading one sample while another is being preflushed and a third is being counted. Standard size sample planchets or filter-paper disks are used. The end-on tube construction provides 2π geometry. Background is said to be 16 to 18 cpm, and both G-M and proportional operation are possible.

IRRADIATION SLIDE RULE

Janet M. Cisar, P. O. Box 1024, Oak Ridge, Tenn. The Isotope Calculator is a circular slide rule designed to be used in solving problems involving build-up of induced radioactivity under irradiation and subsequent decay problems. The calculator, made of plastic, was designed by scientists of the Isotope Division at Harwell, England.

ANALYSIS UNIT

Special Instruments Laboratory, Inc., 1003 Highland Ave., Knoxville, Tenn. Combining a sample changer, absorbers, decade scaler automatic range selector, and a printing recorder in one instrument, the "AutoAnalyzer" is designed for completely automatic measurement of radioactivity. Forty samples in 1-in. copper or nickel-plated steep cups may be loaded at once. Each sample can be measured with any or all of 12 absorbers. Total count is selected automatically for each sample once the desired probable error is set. All results are printed on a paper tape.

LITERATURE AVAILABLE

Recording Instruments. Catalog sheet describes models MR-67A, 61A, and 65A heat-writing recorders. Instruments are designed for use in mv, μv, and $\mu\mu$a ranges. *Millivac Instrument Corp., P. O. Box 3027, New Haven, Conn.*

(Continued on page 88)

RADIATION MONITOR

A New Instrument For Industrial or Laboratory Use—Measures Milliroentgens of Gamma Radiation

- ★ Completely self-contained
- ★ Requires no tubes or batteries—has unlimited life
- ★ Nothing to squeeze or crank. Just turn the instrument upside down and it charges itself
- ★ Voltage easily adjustable to proper value after each charging
- ★ Clear, easy-to-read dial indicates milliroentgens
- ★ Full scale sensitivity 20 mr

SPECIFICATIONS AND PRICES available on request. Let us send you complete information. Write to the *General Electric Company, Section 6120, Electronics Park, Syracuse, N. Y.*

Operator presses discharge button to set to zero. "Memory meter" indicates radiation received between readings.

You can put your confidence in—

GENERAL ELECTRIC

Literature Available (*Cont. from p. 86*)

Helium Cryostat. Apparatus for liquifying gases is explained. *Arthur D. Little, Inc., Cambridge 42, Mass.*

Rotary Switch. Multipole ganged switch for controlling complex circuits is detailed. *Electro Switch Corp., 167 King Ave., Weymouth 88, Mass.*

Fiberglas Bibliography. Annotated references to selected articles are cataloged by use and type of material. *Owens-Corning Fiberglas Corp., Toledo, O.*

Thermometers. Folder describes indicating and recording thermometers. *The Electric Auto-Lite Co., Instrument and Gauge Div., Toledo 1, Ohio.*

Vacuum Pumps. Bulletin V50-A describes single-stage and compound high-vacuum pumps. *Kinney Mfg. Co., Washington St., Boston 30, Mass.*

Present State of Nuclear Physics (*Cont. from p. 20*)

flux of 3×10^8/cm²/sec, corresponding to a reactor power of 250 watts, was reported. The method was used to detect boron impurities in carbon, with a threshold of sensitivity of 1 part in 10^7.

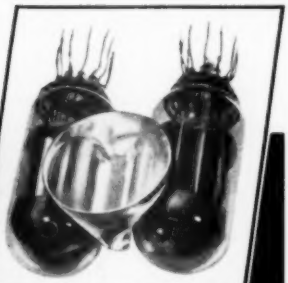
Dr. E. W. Titterton (AERE), in discussing the slow-neutron ternary fission of U^{235}, reported on a study of some 600,000 fission events in photographic emulsions Events where the third track had a range of less than 20 microns were excluded. It was stated that the energy released in ternary fission is equal on the average to that of binary fission. No fission resulting in three approximately equal fragments was observed. The results were interpreted as indicating the formation of an alpha particle symmetrically between the two heavy fragments. It is believed that an n-α reaction followed by fission is precluded. One event, from U^{235}, was interpreted as showing a Be^8 nucleus emitted from the fission with 20 Mev.

An impressive group of theoretical physicists discussed the present state of the theory of the nucleus. This group included *Prof. N. Bohr* (Copenhagen), *Prof. P. Dirac* (Cambridge), *Prof. R. Peierls* (Birmingham), *Prof. M. Pryce* (Oxford), *Prof. A. Pais* (Princeton), *Prof. S. Devons* (London), *Prof. B. Ferretti* (Rome), *Prof E. Wigner* (Princeton), and others. Peierls, in opening the discussion, reviewed the status of the "compound nucleus" theory. Wigner presented an excellent summary of the virtues and faults of the "shell" and "powder" models, and the interpretation of "magic" numbers by Mayer's theory. The "shell" model is most satisfactory for elements close to magic numbers, but digresses rapidly otherwise. Bohr pointed out that the interchange of energy between nuclear particles may be so fast that the "energy level model" may not be possible. In fact, no model presently exists which explains the known experimental results. He suggested the desirability of an entirely new concept of the nucleus.

* * *

It is extremely regrettable that, even in such a select conference as this one, the necessity for alternate sessions existed. The best results from discussions at this level occur when theoreticians and experimentalists can present their ideas and results to each other. It is far less fertile when experimentalists speak only with their colleagues and theory is discussed only by theoreticians. Has the field of physics passed the critical mass so that fission is essential? Let us hope that this is one reaction that we can control.

Phosphors for
SCINTILLATION COUNTING



Example of the use of a solid plastic phosphor for coincidence counting with two photomultiplier tubes.

TRACERLAB now has available two versatile and highly efficient phosphorescent materials for use in scintillation detector units. One is synthetically grown stilbene crystal and the other is a new solid plastic phosphor. Single stilbene crystals up to one inch in any dimension are readily available and can be supplied in precisely machined forms.

The new solid plastic phosphor consists of a terphenyl solution in polystyrene. While plastic phosphors do not give as large pulses as stilbene, their primary advantage lies in the fact that they are available in a large variety of sizes and shapes and are considerably less expensive than crystalline phosphors. For further information write for bulletin N-30.

Tracerlab

Western Division
2295 San Pablo Ave., Berkeley 2, California
New York Office
General Motors Bldg., 1775 B'way, N. Y. 19
Midwest Office
LaSalle-Wacker Bldg., 221 N. LaSalle, Chicago

TRACERLAB INC., 130 HIGH STREET, BOSTON 10, MASS.

We have—

AVAILABLE FOR IMMEDIATE DELIVERY AT LOW PRICES

GEIGER
COUNTER TUBES

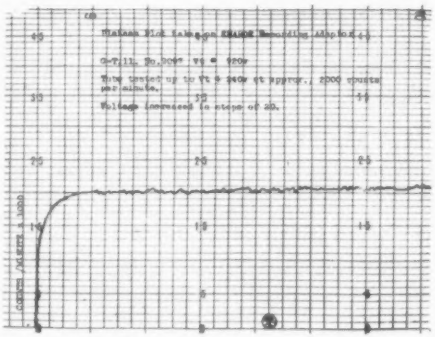
FOR

ALPHA, BETA, GAMMA AND X-RAY DIFFRACTION

Also

SPECIAL TUBES FOR MEDICAL RESEARCH AND FOR MINERALOGICAL WORK WITH POWDERED OR LIQUID SAMPLES

Prices according to type from U.S.A. $6 upwards including packing and postage.



Example of our automatically recorded chart which accompanies each tube showing its performance under test before despatch.

N. R. D. have for many years been suppliers to Government Departments, Universities, Hospitals and Industrial Research Organizations.

Details of other Geiger Counter equipment available on request.

NUCLEONIC & RADIOLOGICAL DEVELOPMENTS
LIMITED

77 KING'S ROAD, LONDON S.W.3. ENGLAND (Cables: "ENARDE," LONDON)

NOW–

read pulse-rates *DIRECTLY!*

—with RCA's "plug-in" COUNT-RATE METER

Type EMA-6

This compact and easy-to-carry instrument indicates *directly* the average number of pulses per second. It is self-calibrating, by means of rectified pulses from the 60-cycle power line. It contains its own high-voltage d-c supply (0-2KV) for use with a wide variety of radiation detectors. It uses no batteries—operates from any 115-volt, 60-cycle, a-c outlet.

The RCA Count Rate Meter is the ideal testing and safety instrument for any industrial plant where radio active material may be present. As a monitor, it can be used to determine the presence of contaminated material. As an assaying device, it can be used to measure the activity of nuclear fuels or isotopes. It can be used for measuring absorption of nuclear radiation by various materials and for detecting the presence of radioactive isotopes in conjunction with tracer work. It can be used to study the characteristics of radiation detecting devices.

The instrument is complete with AN connector and six feet of coaxial cable for connection to a radiation detector. A phone jack for aural monitoring is also included. For complete information write Dept. 126L, RCA Engineering Products, Camden, N. J.

◀ **Count-Rate Meter, Type EMA-6.** *Selector switch permits choice of full scale counting rate of 10, 100, or 1000 per second.*

SCIENTIFIC INSTRUMENTS
RADIO CORPORATION of AMERICA
ENGINEERING PRODUCTS DEPARTMENT, CAMDEN, N.J.

In Canada: RCA VICTOR Company Limited, Montreal

SEARCHLIGHT SECTION

(Classified Advertising)

EMPLOYMENT: "OPPORTUNITIES" :EQUIPMENT
BUSINESS: :USED OR RESALE

UNDISPLAYED RATE

(Not available for equipment advertising)

$1.50 a Line, minimum 4 lines. To figure advance payment count 5 average words as a line.

INDIVIDUAL EMPLOYMENT WANTED undisplayed advertising rate is one-half of above rate, payable in advance.

Box Numbers count as one additional line.

Replies are forwarded each day as received at each of the offices mentioned without additional charge.

Discount of 10% is allowed if full payment is made in advance for 4 consecutive insertions.

DISPLAYED RATE

The advertising rate is $15.00 per inch for all advertising appearing on other than a contract basis. Contract rate quoted on request.

An advertising inch is measured ⅞ inch vertically on one col., 3 col.—30 inches to a page.

New advertisements received at the New York office, 330 West 42 St., N. Y. 18, by December 20th will appear in the January issue

NUCLEAR PHYSICISTS
ELECTRONIC ENGINEERS

Senior staff positions are now available in laboratory with an expanding nuclear and electronics research program. Opportunities exist for basic and applied research in these fields. If interested please send resume. Interviews may be arranged in Boston, New York, Washington, and Chicago.

Bendix Aviation Corporation Research Laboratories
4855 Fourth Avenue, Detroit 1, Michigan

For Sale DEAERATOR TANKS

23 unused ¾₁₆" natural rubber-lined deaerator tanks, 11′ –O″ diameter by 56′ –O″ long, designed for 50# PSI internal pressure, ASME Code, capacity 40,000 gals. May be used as:

- Cold water wood slat deaerators
- Cold water wood slat scrubbers
- Acid storage (rubber-lined)
- Gas absorption
- Gas extraction
- Storage of edible liquids
- Smoke and gas control

For specifications contact . . .

GEORGE R. MARVIN COMPANY
1601 Taylor Way Tacoma, Washington

PROFESSIONAL SERVICES

ATOMLAB
Comprehensively serving The Nuclear Laboratory
RADIATION DETECTION
AND MEASURING INSTRUMENTS
(Catalog on Request)
Uranium metal and compounds — Mass Spectrometers
Rare Earths — High Vacuum Systems
Laboratory: Center Moriches, Long Island, N. Y.
Sales offices: 489 Fifth Ave., New York 17, N. Y.

New Advertisements
received by December 20st will appear in the January issue, subject to space limitations.
Classified Advertising Division
NUCLEONICS
330 W. 42nd St., New York

NUCLEAR RESEARCH CORPORATION
Consulting Nuclear Physicists
112 S. 16th St., Phila. 2, Pa.
LOcust 7-0342

S.S.WHITE 80X HIGH VOLTAGE RESISTOR

(½ Actual Size)

4 watts · 100 to 100,000 megohms

S.S.White 80X Resistors have many characteristics—particularly negative temperature and voltage coefficients—which make them suitable for many high voltage applications.

They are constructed of a non-hygroscopic mixture of conducting material and binder which assures adequate mechanical strength and durability. A coating of G-E Dri-Film further protects them against humidity and helps to stabilize them.

BULLETIN 4906 has full information. Write for a copy today.

THE S.S.White INDUSTRIAL DIVISION
DENTAL MFG. CO.

Dept. 2 10 East 40th St.
NEW YORK 16, N. Y.

INDEX TO ADVERTISERS

General Electric Company
Apparatus Dept. 4
Electronics Dept. 87
Kelley-Koett Instrument Co. . . 3rd cover
Nuclear Instrument & Chemical Corp. . . . . 4th cover
Nuclear Research Corporation 94
Nucleonic & Radiological Developments, Ltd. 90
Penberthy Instrument Co. 93
Professional Services 92
Radio Corporation of America 91
Searchlight Section 92
Tracerlab, Inc. 89
Victoreen Instrument Co. . . . . 2nd cover
White Dental Mfg Co. S.S. 93

For Gamma and X-Ray Protection, *Hi-D Glass windows permit excellent wide-angle vision through thicknesses up to 10" or more, with a lead equivalent of 0.56, steel equivalent of unity.

*Trade Mark

PENBERTHY INSTRUMENT CO.
666 Adams St., Dept. N
Seattle 8, Washington

NUCLEAR RESEARCH CORPORATION

Announces

a ***NEW***, outstanding method for the detection of Alpha, Beta and Gamma radiation.

The **NRC** Scintillation Geiger Counter* combines high efficiency scintillation techniques with the inherent advantages of the Geiger-Mueller photoelectric tube

NOW AVAILABLE!

The **NRC ALPHA** Scintillation Counter Tube* for health physics and general applications.

(First of a series.)

Model NRG-S10A
Standard type — 2″ sensitive volume (5½″ o.l. x ⅞″ diam.) $57.50

Model NRG-S15A
Portable Survey Type — 2″ sensitive volume (5″ o.l. x ⅝″ diam.) $57.50

The **NRC *ALPHA* SCINTILLATION TUBE** features these outstanding advantages:

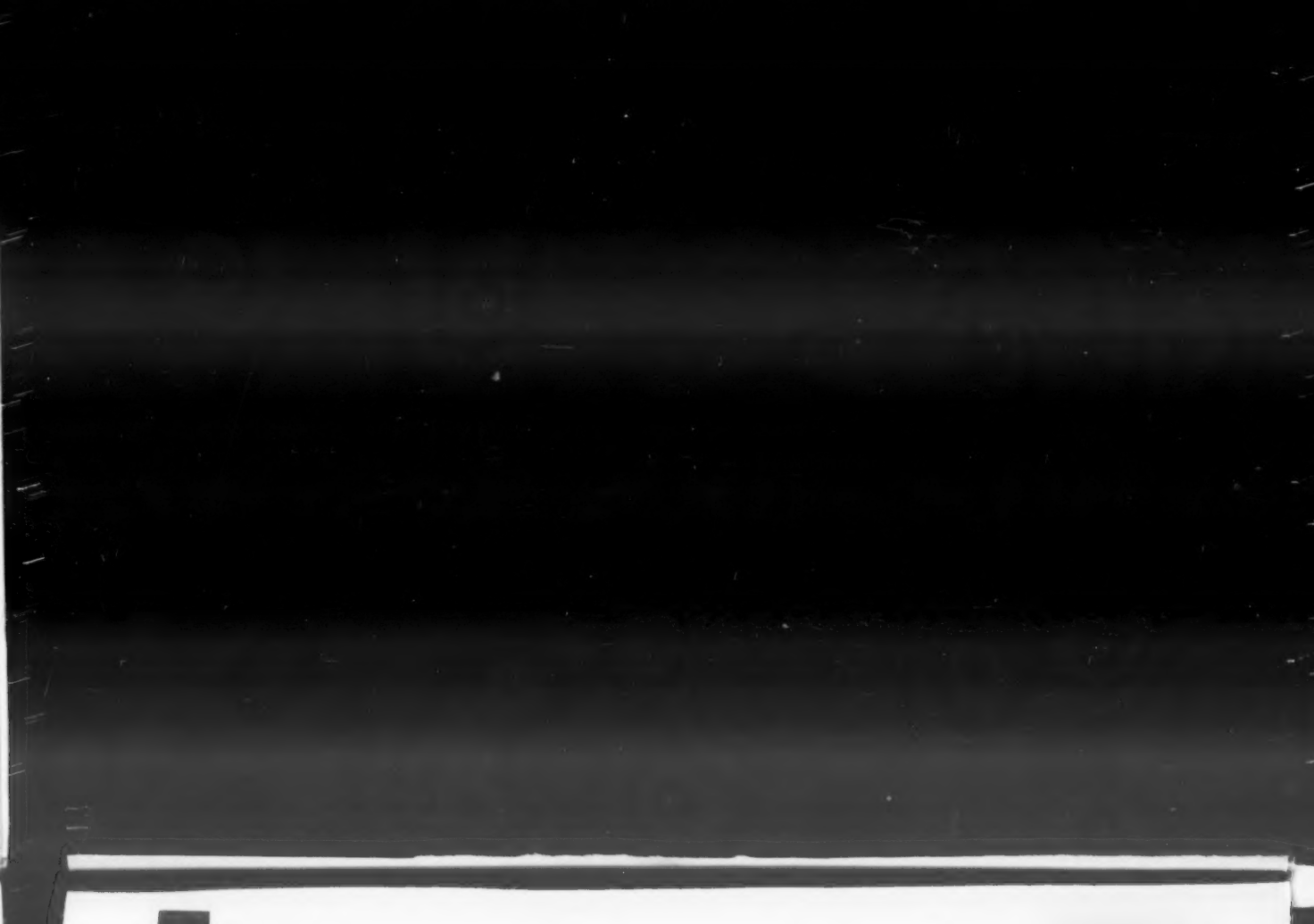
- 360° solid angle of detection
- Essentially 100% efficiency for alpha particles of energy >4MEV
- Light-tight foil not necessary for operation at normal room light levels
- Stable phosphor coating
- Rugged tube construction—long plateau
- Stable operation over long life
- Short resolving times, 850–1,000 volt operation
- Low GM background

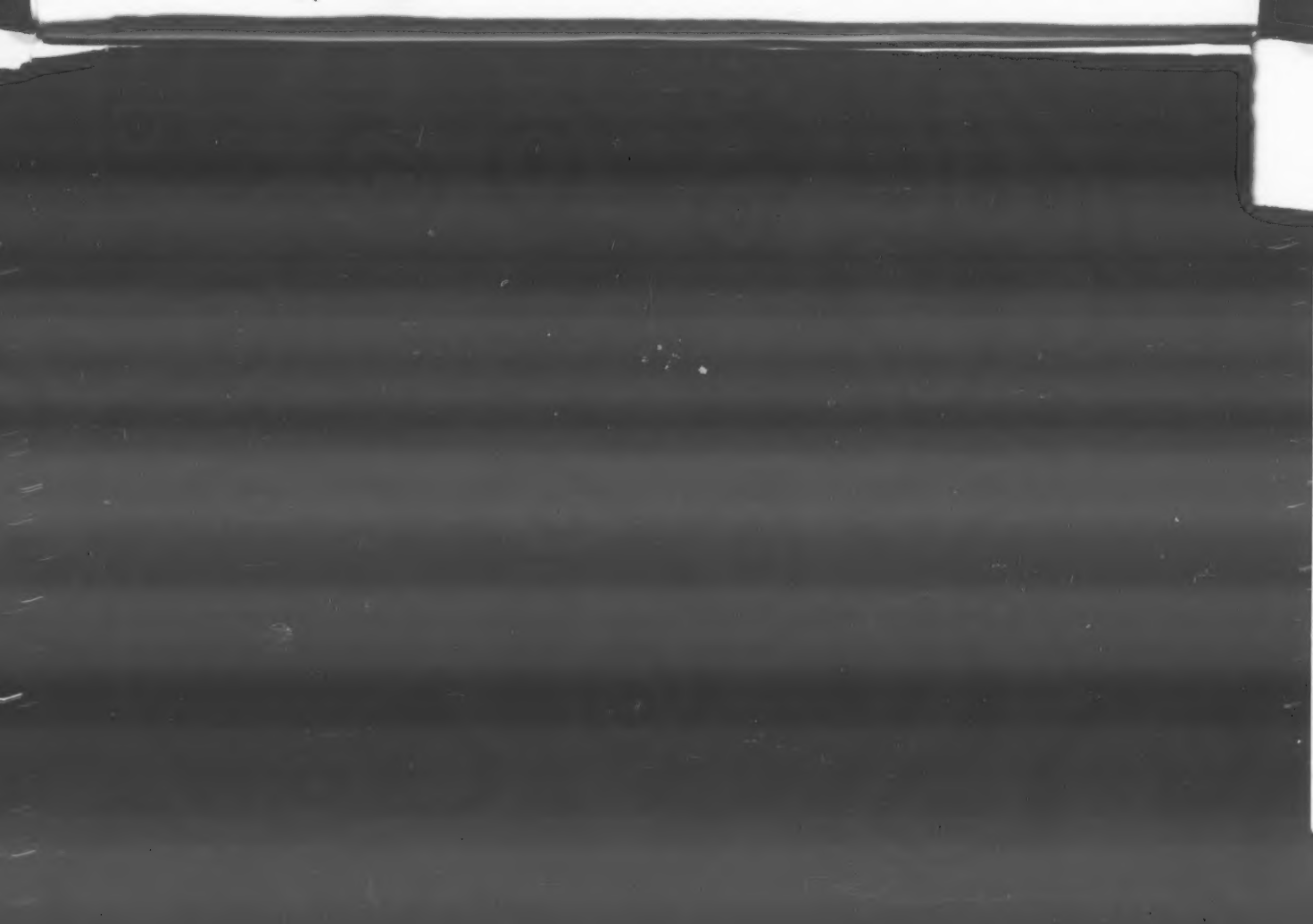
Write for further information

COMING! A complete integrated series of NRC Scintillation Geiger-Mueller instruments for the high efficiency detection of alpha, hard and soft beta, and gamma radiation.

*Patent applied for

NUCLEAR RESEARCH CORPORATION
112 SOUTH 16th STREET • PHILADELPHIA 2, PA.





Guide for Selection of

Equipment for Radioactivity Laboratories

INTRODUCTION

WITH THE RECOGNITION of the possible advantages of radioactive materials, there has come a considerable increase in their use. Evidence of this interest is the fact that over the past several years, the Editors of NUCLEONICS have had innumerable requests for information on equipment for radioactivity laboratories. On the basis of these requests and general interest in the subject, we have brought together in this issue reports from six men who are particularly familiar with this field.

As is now fairly well known, the use of radioactive materials introduces two problems into the laboratory: radiation hazards and contamination. Much has yet to be learned about these problems. However, with proper technique and suitable equipment, the potential hazards and contamination can be held to the desired minimum.

In general, proper technique comes from the use of common sense along with an adequate knowledge of the experimental factors involved.

A primary problem for new users of radioactive materials has been the design or selection of equipment for their laboratories and, in many cases, the design of new laboratories or the redesign of old facilities. One of the difficulties has been that much of the equipment needed has not been available from standard suppliers. Or, if the equipment is available, there has been the problem of locating a supplier.

This Guide is divided into three major sections with a total of six parts:

$<$ 1 mc: α-emitter (e.g. U^{238}, Cm^{242})
soft β-emitter (C^{14}, also S^{35}, Ca^{45})

1 mc–1 c: γ-emitter (Co^{60})
β-emitter (P^{32})

$>$ 1 c: physical, chemical problems

In each of these parts, for a typical problem, we have listed equipment which is of particular interest for the problem in question. There is much equipment which is common to all of the problems described. The Editors have removed such items from each of the authors' contributions and have placed them in a "general" section which precedes the rest of the Guide.

It should be pointed out that the primary purpose of this Guide is as the name indicates—to serve as a "guide." We have found that there are differences of opinions among the various people working in this field as to how a laboratory should be designed and what should go into it. Therefore, the following tables are meant only to be a guide, a source of information.

To complement the equipment tables, our Research Staff has compiled a very extensive Buyers' Guide, which follows page R-24. In this Guide can be found the source of supply of every item listed in the tables plus other products of interest.

—The Editors

MATERIALS

Coatings, protective.

Paints, protective. Make exposed surface of base structural material nonporous, chemically resistant, easy to decontaminate. Plastic, resin, standard oil base paints usable.

Paints, corrosion resistant. Can be applied to wood, concrete, plaster, metal. Excellent resistance to corrosion.

Paints, strippable. To cover areas exposed to activity. Absorb surface contaminants. Easily applied and removed; discarded. Second layer over contaminated area forms sandwich which can be stripped off. Porous, not resistant to chemical attack. Cannot be applied to bare concrete, plaster, or other porous surfaces.

Plastic sheets. Large sheets of polyethane, Tygon, Bakelite, fluorothene, etc. To cover areas exposed to activity. Easily removed and discarded.

Wax. To protect floors from wear, contamination.

Concrete. Structural material. See note below under "Flooring" for limitations.

Flooring.

Concrete, bare. Porous, vulnerable to contamination by liquids and dust. Extremely difficult to decontaminate; not recommended.

Concrete, painted. Difficult to prevent contamination from penetrating paint and getting into concrete; not recommended.

Linoleum. Easily taken up and replaced in case of spill.

Tile, asphalt. Easily removed and replaced in case of spill. "Cold flow" makes joints fairly tight.

Tile, plastic. Generally available. Grease-proof, highly resistant to strong acids and alkalies. "Cold flow" makes joints fairly tight. Easily removed and replaced in case of spill.

Tile, rubber. Easily removed and replaced in case of spill.

Subcoat. Trowelled-on neoprene-like material. Easily patched. Used under tile to prevent penetrating contamination from going further. Too porous to be used by itself as finished flooring.

Wood. Porous. Not recommended by itself.

Paint, sealing. Cover large cracks and gaps to keep dust out. Low resistance to chemical attack.

Paper, absorbent. Expendable protective coating. Use on potentially contaminable surfaces. Facilitates disposal of spilled liquids and radioactive dust. May be blotting paper, "diaper" paper, newspapers; absorbent paper with impervious backing on one side available in rolls and sheets.

Plywood. Structural material.

Plywood, stainless-steel coated. Combines ease of fabrication of plywood with ease of decontamination of stainless steel. Use as structural material or as decontaminable covering.

Stainless steel. Resistant to chemical attack, but attacked by acid halides. Expen-

sive. Otherwise excellent. Recommended for trays, utensils, equipment racks, etc.

Steel, lead-coated. Used in furniture manufacture; should be painted.

Sponges. For cleaning surfaces.

Stopcock grease. Lubricate syringes, other equipment.

Tape, sealing. To cover small areas, seal cracks. Plastic film or paper with pressure-sensitive adhesive. Synthetic rubber tape which fuses only to itself also useful.

Tissues, absorbent. Wipe equipment, wipe up small spills, pick up items which may be contaminated. Use fresh piece each time, discard immediately.

Vaseline. Lubricate syringes and other equipment.

Walls. Inexpensive structural material desirable. Wood, pressed-wood panels, wall board, fiber board, plywood, Masonite, Transite, steel partition panels, metal-clad plywood suggested.

APPARATUS

Air conditioning equipment. Maintain constant temperature and humidity. Keep protective clothing from getting damp and losing effectiveness. Aids proper functioning of counting equipment.

Brushes, scrubbing. To clean hands and contaminated laboratory areas.

Calculators, slide-rule type. Aid in determining activation, activity, shielding requirements.

Charts, isotope. For reference.

Clamps. To hold apparatus in position. Frame of square rods to which clamps can be fixed is useful.

Clothing, laboratory. Special coats, etc., worn only in active areas; help check spread of contamination.

Compressed-air supply. For operating pneumatic devices, glass blowing, ventilating small animal cages, etc.

Frame, clamping. Used with clamps to hold apparatus. Can be set up inside hood or dry box. Square rod preferred.

Glasses, safety. To protect eyes.

Gloves, rubber. To protect hands and help check spread of contamination. Surgical type for delicate operations; heavier ones for decontamination; obstetrical type for dry or glove boxes. Cotton liners under gloves facilitate changing. Talcum powder makes donning gloves easier. Frequent washing recommended, as activity has been known to diffuse through the rubber.

Gloves, heavy neoprene. Worn when washing contaminated areas.

Gloves, cloth. For handling heavy equipment.

Heaters, hot plates. For heating samples, solutions, etc. Also used for evaporating samples onto plates.

Power supplies. To meet instrument requirements.

Pumps, vacuum.

Rubbers, shoe covers. Prevent spread of contamination. Worn in active areas; removed when leaving.

Signs, danger warning. To label contaminated area. Standard magenta radioactivity symbol desirable; type, level of activity, time, date should be marked.

Thermometers. All-metal, dial-head type good for remote observation.

Transformers, variable. For voltage adjustment.

Trays. Used in working and storage areas under equipment to contain spills. Equipment on tray can be moved intact. Stainless-steel, plastic, porcelain, glass, enamelled trays can be decontaminated; painted wood trays disposed of after spill. Lead trays used for storing corrosive reagents.

FURNITURE

Benches, laboratory. Corrosion and abrasion resistant; easily decontaminable. Service lines boxed in to facilitate decontamination. L. G. Stang recommends enamelled lead-coated steel cabinets with stainless-steel tops; G. G. Manov suggests wood or stoneware tops with protective coating to reduce porosity, with proviso that stainless-steel trays be used under equipment.

Cabinets. Corrosion and abrasion resistant; easily decontaminable. Made of wood, Transite, steel, with protective coating.

Chairs.

Desks.

Sinks, laboratory. Easily decontaminable, chemically resistant. Foot- or elbow-operated valves recommended. Deep-drawn or welded, ground and polished stainless steel preferred.

Stools.

Table, glass blowing. For fabrication of apparatus.

Laboratory Equipment • <1 mc, α-emitter

By PAUL FIELDS and D. C. STEWART
Chemistry Division, Argonne National Laboratory
Chicago, Illinois

As with other radioactive substances, the handling procedures used with alpha emitters depend to a large extent on radiation characteristics and the level of activity. But other factors are important too.

For example, a millicurie of U^{238} would involve techniques designed for handling large quantities of materials, since this would represent about a kilogram of substance. On the other hand, a millicurie of Cm^{242} would only weigh about 0.25 μg, and entirely different procedures would have to be used. Similarly, the problems encountered are very much different in handling moderate amounts of activity as contrasted with the case where only 3 or 4 cpm of a new element or of a naturally occurring rare isotope are

available. In the latter example, of course, it is necessary to use extreme care to avoid outside contamination.

Combined with the items in the general listing, those listed here are characteristic of the laboratories of the Argonne National Laboratory Service and Training group.

MATERIALS

Cation and anion ion exchange resins. For separating α-emitters.

Chelating agents. For separating α-emitting elements; for decontamination.

Decontamination reagents. Solvents, chelating agents. For α-decontamination of hands: potassium permanganate and sodium bisulfite, sodium citrate, sodium hypochlorite and dilute hydrochloric acid, and tartrates.

Glass sheet. Useful for covering table tops.

Lime water. Useful for HF burns.

Methane, methane-argon mixture. Gases for use with α-counters.

Parafilm. To cover tubes, small beakers, etc.

Phosphors. To locate areas of high α-activity.

Photographic plates. Special emulsions for determining α-particle ranges, etc.

Pycene (in benzene solution). For making organic rings on outer rims of plates. Zapon solution also used.

Rare-earth salts. Carriers for actinide elements.

Soap, green. Low alkaline soap for first wash to remove activities forming alkaline precipitates.

Solvents. For separating α-emitting elements; for decontamination.

Tetraethylene glycol. Spreading agent used in sample preparation.

Thorium. Typical α-emitting element. Useful for standards, etc.

Uranium. Typical α-emitting element. Useful for standards, etc.

Zapon solution. For making organic rings on outer rims of plates. Pycene in benzene solution also used.

APPARATUS

Absorbers. Aluminum or mica. Cut out α activity if associated Geiger activity is being measured.

Assault masks. Worn when entering area of accident.

Automatic sampling devices. Used with ion-exchange columns.

Beakers, stainless steel. To reduce breakage hazard when working with valuable isotopes.

Centrifuge, clinical. With adaptors. Used for separating precipitates in small tubes (1–50 ml).

Centrifuge, micro. Air driven. Used with very small cones. Very high speed—about 25,000 rpm.

Centrifuge cones.

Macro. Glass, stainless steel, Lusteroid; useful sizes range from 5 to 100 ml.

Micro. Glass, Teflon, Lusteroid; useful sizes range from 0.2 to 5 ml.

Columns, ion exchange. Many α-emitters best separated by ion-exchange techniques.

Cover slips. Microscope slide type. For mounting samples which do not require flaming.

Disks.

Glass. To mount samples which do not require flaming. Less fragile than cover slips.

Stainless steel. To mount samples which must be flamed but do not attack stainless steel.

Platinum. To mount samples which must be flamed and for liquids which attack stainless steel.

Disk holder. Rotating type. To obtain uniformly spread samples.

Distillation apparatus. Used to free liquid reagents and solvents from possible α-activity.

Dropping bottles. For reagents.

Dry boxes. For handling dry radioactive materials.

Electric stirrers.

Face shields.

Flasks, volumetric. For dilution of solutions before assay. Useful sizes: ordinary macro, 5–1,000 ml; micro, 0.1–5 ml; straight-walled tubes, 1–2 ml.

Fluorothene beakers, tubes. Used for HF solutions.

Forceps. For handling active plates and equipment.

Glass blowing equipment.

Hair drier. Used to evaporate solutions containing slightly volatile components.

Heat lamp. Infra-red type. To evaporate samples on disks.

Heater, induction. For sample preparation; evaporating volatile solvent in center of plate.

Lusteroid tubes. Used for HF solutions.

Microbalance. Quartz-fiber type. Used to weigh samples of 0.05–200 μgm.

Micro bunsen burner. To ignite samples on plates.

Microburette. Up to 100λ in 0.01λ graduations for micro titrations.

Micro furnace. Used to ignite small samples.

Micro manipulators. To manipulate various equipment in carrying out chemical reactions under microscope.

Microscope. Binocular type. Wide angle vision with ~15–100 times magnification. Used to observe reactions and manipulations on micro scale.

Microscope stage. Used to hold samples for observation under microscope. Has manipulator attached to move sample.

Micro torch. For small-scale glass blowing.

Petri dish. Covered; to store plates.

pH meter.

Pipettes, micro.

Calibrated to contain. Self-filling, transfer, 1–10λ; self adjusting, transfer, 1–100λ; volumetric dilution type to dilute aliquot to larger volume; standard transfer type, 1–500λ.

Calibrated to deliver. Graduated, measuring pipette, 5–250λ divisions depending on size.

< 1 mc, α-emitter

Pipettes, transfer. Uncalibrated; used in transferring supernatants, etc. Usually homemade.

Pipette cleaners. Micro size. Used for sucking glass cleaning reagents through pipettes.

Plate holders. Used to mount samples.

Platinum dishes, crucibles, etc.

Polyethane bottles. Used to store HF solutions.

Spot lights. Used to illuminate micro vessels in conjunction with microscopes or micro titration.

Stirrer. Vibrating type. To stir very small amounts of solution being titrated with microburette.

Syringes. Sizes ranging from 1 to 100 ml; for filling pipettes without resorting to mouth suction.

Test-tube rack. Stainless steel. Can be readily decontaminated.

Tongs. For handling active plates and equipment.

Tweezers. For handling active plates and equipment.

Ventilated enclosures.

Fume hoods.

Desk hoods. For limited amounts of active material.

Vacuum-line hoods. To enclose vacuum lines used for active products.

Glove box. Essentially a ventilated dry box.

Ventilated cabinets. For storage of active samples.

Volatization apparatus. High temperature and high vacuum. Used to prepare thin films of α-emitting substances.

Waste containers.

Paper-lined garbage cans. For dry active waste.

Large bottles. In metal secondary container. For liquid waste.

Drums. For liquid waste.

Cartons, ice cream. For dry active waste.

Wire, platinum. Used as stirring rods on small scale.

INSTRUMENTS

Alpha counters. Air counters have range of about 1–10,000 cpm; flowing gas counters have range of about 1–500,000 cpm.

Alpha pulse analyzer. Device for determining number of α-particles of a given energy.

Air sampler. "Queenie." Used to detect α-activity in atmosphere.

Differential range counter. Used to determine α-particle ranges.

Ionization-chamber counters. For very active samples.

Low-geometry counter. Can be constructed for almost any range.

Standard α-sources. For calibration, reference.

Survey instruments.

Portable probe. Detects about 100–40,000 α-disintegrations/min.

Zeus. Detects about 2,000 to 2×10^6 α-disintegrations/min.

Zeuto. Detects about 100–40,000 α-disintegrations/min.

Laboratory Equipment • < 1 mc, β-emitter

By GEORGE G. MANOV
Chief, Advisory Field Service, Isotopes Division
U. S. Atomic Energy Commission, Oak Ridge, Tennessee

THE PURPOSE of this discussion is to present the features with respect to construction, equipment and instrumentation which are generally desirable for a laboratory using weak beta-ray emitters such as C^{14} (0.15 Mev). While C^{14} is used throughout as an illustration, S^{35} (0.17 Mev) and Ca^{45} (0.25 Mev) are other examples of pure beta-ray emitting radioisotopes falling within approximately the same energy range as C^{14}. The design of a laboratory for use with S^{35} and Ca^{45} would not differ significantly from one using only C^{14}.

Radioisotopes that emit only weak beta rays (below 0.3 Mev) present no particular hazard with respect to external radiation. On the other hand, the isotopes named above are considered hazardous from the standpoint of internal radiation or from ingestion, either because they localize in a specific tissue or because they have a slow rate of biological turnover (*1*).

The design of a laboratory appropriate for use with C^{14}, S^{35} and Ca^{45} should, therefore, stress the need for such items as specially designed hoods, glove boxes, and particularly, special-purpose instrumentation including very thin end-window counters for making measurements of radioactivity. Heavy shielding such as lead bricks, remote control handling equipment, film badges, and other special materials are not required.

Contrary to early designs, it is not necessary that hoods be made of stainless steel. Cheaper materials, coated with a protective finish (*2*), are usually adequate. The working surface of the hood, however, should preferably be made in the form of a stainless steel pan. Water-washdown and auxiliary air baffles at the back of the hood are not now considered necessary.

The shielding and safe-handling requirements are very simple. Surgical rubber gloves are sufficiently thick to stop the beta radiation from C^{14}, S^{35} and Ca^{45}. These isotopes are best handled in glove boxes or in a hood to reduce the possibility of hazard from ingestion.

Disposal of waste radiocarbon should be made in accordance with available interim recommendations (*3*) in which a value of 10^{-2} μc/liter of $C^{14}O_2$ in air is given as the maximum permissible concentration.

* * *

The assistance of O. M. Bizzell and C. R. Buchanan in compiling part of the tabular material is acknowledged.

BIBLIOGRAPHY

1. "Safe Handling of Radioactive Isotopes," Handbook 42 (National Bureau of Standards, Washington, D. C., Sept., 1949. Available from Supt. of Documents, Government Printing Office, Washington D. C.)
2. O. M. Bizzell, P. C. Tompkins, C. D. Watson. Working surfaces for radioisotope laboratories, *Ind. Eng. Chem.* **42**, 1469, 1475 (1950); also: Practical aspects of surface decontamination, NUCLEONICS **7**, No. 2, 42 (1950)
3. Interim recommendations for the disposal of radioactive wastes by off-commission users, NUCLEONICS **8**, No. 2, 22 (1949); also *Circular B-6*, Isotopes Division, U. S. AEC, Oak Ridge, Tenn.

< 1 mc, β-emitter

MATERIALS

Decontamination reagents. Dilute mineral acids, detergents, etc. Should be cheap, efficient.

Film. For autoradiographic studies. High sensitivity, good resolution desirable. Photographic plates also used.

Isotopes. For tracers, syntheses, etc. C^{14}, S^{35}, Ca^{45} are beta emitters.

Labeled compounds. For tracers, syntheses, etc. Both inorganic, organic compounds available.

Plastics. To shield against beta radiation. Should be corrosion resistant, light weight. Lucite, Plexiglas, Bakelite, etc., suggested.

Sources, C^{14}. Beta emitting solids. $BaC^{14}O_3$ plus carrier, C^{14}-labeled polystyrene sheets available with 1 μc activities.

Standards, C^{14}. Standardization of instruments, etc. Solution of $Na_2C^{14}O_3$ plus carrier available in 5 ml (1 μc) quantities.

Wire mesh. For construction of laboratory apparatus. Easily decontaminable. Stainless steel, copper, aluminum suggested.

APPARATUS

Air filters. To remove radioactive particulate matter, maintain dust-free atmosphere. Should be low in cost, expendable; glass-wood fibers suggested.

Animal cages. Housing of radioactive experimental animals. Easily decontaminable; provision for collection of excreta. Stainless steel, steel, copper, or plastic suggested.

Ashing dishes. Expendable or easily decontaminable. Porcelain, platinum suggested.

Balances. Pulp, analytical, microchemical for laboratory weighing. Should be easily decontaminable.

Beaker tongs, etc. For handling contaminated containers, radioactive solutions. Should be easily decontaminable. Stainless steel suggested.

Blowers. Standard, but easily decontaminable. For glove-box exhaust.

Cabinets, sample storage. Optional equipment; about $14 \times 12\frac{1}{2} \times 10$ in.; weigh approximately 26 lb. For storing radioactive samples.

Centrifuge. Standard model, completely enclosed to prevent spread of contamination. Stainless-steel refrigerated and enclosed centrifuge optional.

Containers, isotope storage. Optional equipment, made of lead, iron to provide shielding. Sizes vary; common are $8 \times 8 \times 10$ in.; $6 \times 6 \times 8$ in.; $4 \times 4 \times 6$ in.; weights from 30 to 225 pounds.

Glass, quartzware. Standard apparatus. Nonporous, heat resistant.

Glove box. For safe handling of radioisotopes; prevents spread of contamination. Approximate size: $36 \times 18 \times 24$ in. Made of wood, stainless steel, steel. Small blower maintains slight negative pressure within box.

Hoods, chemical. External controls desirable; accepted airflow characteristics are 50–80 ft/min; should be easily decontaminable. Can be made of wood, Transite, steel, stainless steel.

Hoods, glassed-in. California type. For synthesis of organic C^{14} compounds; prevents spread of contamination. Easy access to apparatus required. Air

flow characteristics as above. Can be made of wood and glass, steel and glass. Approximate size: 3 × 6 × 6 ft.

Microchemical equipment. Usually glass. Should be flexible, easily decontaminable.

Planchets. For evaporating and mounting radioactive samples. Should be easily decontaminable or low in cost and expendable. Platinum or stainless steel; copper, steel, aluminum suggested.

Respirators. Prevent ingestion of radioactivity; must retain small particles. Filter paper useful in making respirators.

Screens, sieves, shakers. Made of stainless steel; completely enclosed, mounted in fume hood.

Trays, sample. Containers for radioactivity. Permit better material control; minimize cross contamination. Should be inexpensive, easily decontaminable. Glass, porcelain, stainless steel suggested.

Ventilators, fans. Standard models to supply adequate air for hoods, etc. Should be corrosion resistant.

Waste containers. For temporary storage of waste radioactivity. Must be easily decontaminable.

Dry wastes. Step-on garbage can.

Liquid wastes. Glass carboy, or stainless-steel tanks.

INSTRUMENTS

Instruments such as film rings, film badges, pocket chambers, and dosimeters normally used for personnel monitoring are insensitive to radiations from C^{14}, S^{35}, Ca^{45}, and are therefore omitted from this list.

Survey and monitoring instruments. Necessity. Portable. Window thickness preferably less than 3 mg/cm². Usable meters have ranges of 0–20,000, 0–10,000, 0–50,000, 0–60,000 cpm, and 1–20,000, 0–20 mr/hr.

Air monitor. For checking radioactivity of air. Measures activity of 3 ft³/min. Sample cylinder 7½ × 7½ in.

Scaler. Necessary measuring instrument. Range of 0–130,000 c/sec required.

Thin end-window G-M tubes. Desirable for quantitative measurement. Window thickness 3 mg/cm² or less.

Gas-flow counting unit. Optional quantitative equipment.

Proportional counting unit. Optional quantitative equipment.

Scintillation counter detector. Optional quantitative equipment.

Vibrating-reed electrometer. Optional quantitative counting equipment.

Sample, G-M tube holders. Necessary accessories; provide reproducible geometry for quantitative counting.

Lead shields. Desirable accessories for counters; provide shielding against background.

Absorbers. Desirable accessories. Aluminum, mica, lead. Useful sets have ranges of 1.5–4.4 mg/cm²; 0–80 mg/cm²; 0–1,500 mg/cm². Used for differentiating between radiations.

Laboratory Equipment • 1 mc—1 c, γ-emitter

By LOUIS G. STANG, Jr.
Hot Laboratory Operation Group
Brookhaven National Laboratory, Upton, New York

THE TYPES OF MATERIAL and equipment needed to handle radioactive material depend in large measure, as the divisions of this series of articles indicate, upon the amount of activity involved. This section discusses the various items used in handling a gamma emitter in the intermediate range (1 mc to 1 c). Cobalt-60 is a typical gamma-emitting isotope used in this range.

This isotope is formed by irradiating stable Co^{59} with thermal neutrons in a chain-reacting pile. It decays with a half-life of 5.3 years to stable Ni^{60} by the emission of a β^- particle of 0.31 Mev energy. Each of these β^--particles is accompanied by two γ-rays, one having an energy of 1.332 Mev and the other 1.171 Mev.

Within the range of activities considered here, different techniques are used for different types of work. Broadly speaking, the kind of work generally encountered may be divided into two classifications:

Physical manipulation of solid sources for irradiation purposes such as industrial radiography (detection of flaws in castings, etc.), therapeutic treatment in which Co^{60} replaces the more familiar radium for cancer treatment, and research work on the effects of radiation.

Chemical manipulation in which a compound is "tagged" with Co^{60} for use either as a tracer material or as a source of radiation. Such compounds are often prepared in the form of a solution, the handling of which falls into the chemical manipulating class.

Some of the equipment needed for these types of work is outlined here. Whether the items mentioned are applicable to physical or chemical manipulations is usually evident.

MATERIALS

Adhesives. For fixing source to base material: choice depends on conditions.

Waxes. Du Pont "Parlan," the apiezons, paraffin, fluorothene waxes useful; fluorothene inert to all chemicals except molten alkali metals.

Cements. Ordinary lacquers, de Khotinsky cement useful.

Coatings, protective, for source.

Fluorothene, Teflon containers. Excellent for severe corrosive conditions: easily machined, self-gasketing. Now available in form of paints; can be sprayed directly into source (before irradiation).

Glass, other plastics. Sometimes used, depending on conditions.

Gold plate. Applied to cobalt (and other) sources to prevent subsequent corrosion and contamination.

Lacquer. Sometimes substituted for gold plate.

Metal containers. Aluminum, brass, platinum, gold, lead cans prevent corrosion, contamination. Hooks or eyes facilitate handling. Wall thickness

of only a few tenths of a millimeter will filter out the primary β -particles, leaving relatively pure γ source.

Decontamination reagents. Suggested are: 1. soap and water, 2. steam, 3. ammonium citrate-citric acid mixtures, 4. trisodium phosphate, 5. sodium hydroxide, 6. nitric acid, 7. aqua regia, 8. chromic acid, 9. hydrochloric acid. For removing Co^{60} contamination, any strong acid effective.

Film, photographic plates. Personnel film badges discussed under "Instruments." Ordinary X-ray film useful for determining absolute dosages at given point, uniformity of radiation level in given plane or at given surface. (Since film is more sensitive to lower-energy radiations—scattered or secondary rays—exercise caution in interpreting results.)

Plastics. Useful as containers for their transparency, color, general ease of fabrication, corrosion resistance. Afford no shielding against γ-rays.

Quartz, sputtered. Recommended for inside plastic vessels where liquid-wet vessel walls desired.

Shielding materials.

Concrete. Satisfactory, structurally good for both temporary block walls and permanent cast walls; must be protected from contamination.

Lead. High density, superior to concrete where space must be conserved. Many different shapes proposed for bricks which interlock: several in actual use. Interlocking feature prevents direct beam of radiation from leaking through cracks in bricks, which would occur if poorly fitting rectangular bricks were used. But if reasonable care used to prevent denting and consequent improper stacking, simple rectangular shape is preferable from cost, inventory standpoint. Width and length should be multiples of thickness. Double row of bricks permits staggering of joints to avoid straight-through crack.

Lead wool. Lead turnings in form resembling steel wool: useful for caulking holes, cracks in shields.

Cast iron, steel. Combine relatively high density with good structural properties; give fairly compact shield; require no special care in handling; nonporous, not difficult to decontaminate. Cast iron will not rust under normal conditions, but both should be coated if conditions at all corrosive.

"Hevi-Met." Alloy of 90% wolfram, 6% nickel, 4% copper; density 16.8–17.0 gm/cm.^{3} For 2-Mev X-rays or γ-rays, one inch gives same shielding as 1.5 inches lead. Very expensive; therefore, suitable for small specialized shields only.

Aluminum. Has been proposed in place of concrete. Easier to decontaminate, has same density; could be used like concrete for stacking large walls. Higher price not offset by advantages.

Wood, paraffin, water, sand. Effective as neutron shields; inefficient for γ-shields. In general, not recommended here, except that if a water-filled canal or well available, manipulations sometimes performed to advantage under water.

Zinc bromide. Solution can be made having same density and shielding power as concrete; for filling "aquarium" windows in concrete walls, permitting direct visual observations.

Shielding materials (continued).

Lead glass. A new type has good optical properties, slightly better shielding characteristics than solid steel. Commercially available.

Special shields. When special shape needed in hurry, container can be made of wood or sheet metal, filled with lead or steel shot, or sand.

Silicones. Grease used as stopcock lubricant; oil used as antiwetting agent on glassware.

Tubing.

Glass. Excellent resistance to all reagents except acid fluorides and strong alkalies. Fragile; recommended only for lines which carry strong acids which are not subject to mechanical or thermal shock.

Fluorothene. Can be worked like Saran; attacked only by molten metallic sodium and potassium; swells but does not dissolve in contact with chlorinated hydrocarbons; expensive.

Rubber. Deteriorates on standing; soluble in many organic solvents; hardens in strong acids; recommended only for temporary set-ups.

Saran. Semirigid, translucent, resistant to most reagents; can be connected by welded or by flare fittings. Also in form of rigid pipe.

Tygon. Nearly transparent; almost as flexible as rubber; does not deteriorate with age; unaffected by many reagents; concentrated strong acids and bases will harden it with time; chlorinated organic solvents soften or dissolve it; generally recommended.

Valves, stopcocks. Should be compact; liquid hold-up minimized; adaptable to remote operation; material resistant to strong acids and bases; greaseless and packless. None commercially available which fulfill all these requirements.

Ventilation ducts. Should be smooth inside with joints and seams reduced to minimum; capable of withstanding fumes encountered and decontamination reagents. Stainless steel, painted mild steel, painted Transite recommended.

APPARATUS

Air filter. Exhaust air from chemical processing areas filtered to minimize release of radioactive dust and spray. Supply air filtered to avoid loading up exhaust filters faster than necessary.

Balances. Model recently made available has weights put on and taken off by rotating one or more handles. Useful for making quick weighings of radioactive material—cut operator exposure time to minimum. Can also be easily converted to remote-control operation from behind a shield.

Containers, lead. Size varies with use. For housing small, 1-c Co^{60} source, would be about 19 cm in diameter, 21 cm high, would weigh 150 lb and reduce radiation level to 10 mr/hr 3 ft from center of shield.

Dry boxes. Ordinary boxes unsuitable for Co^{60} in amounts greater than few mc; up to 40–50 mc can be handled if box large enough to permit use of tongs and exposure times short. Shielded boxes using manipulators mounted on ball-and-socket joints are preferred.

Glass, quartzware. Standard heat-resistant laboratory accessories required. Quartz preferred to glass for sealing up samples to be irradiated in pile—free of sodium, component which gives rise to most of activity in irradiated glass.

Gloves, aprons, lead. Shielding equivalent to approximately 0.5 mm lead; not adequate for more than 1 mc Co^{60}.

Gold-plating bath. Recommended for laboratory in which many solid Co^{60} sources handled.

Grasping devices.

Tongs, tweezers, forceps. Various surgical instruments useful for handling sources. Light, easily handled, commercially available.

Hemostats. For picking up objects with firm grip. For pinching rubber tubing closed from distance.

"Mechanic's tongs." Consist of tube about 12 in. long with pair of spring jaws at one end—opened by squeezing grip at other end. Commercially available; easily modified to any desired length.

Suction hose. Rubber tube suspended on cord or held in long tongs; connected to vacuum. Used for picking up objects with at least one flat surface exposed.

Heaters. Quartz-covered immersion heaters for heating large vessels internally. Infra-red heat lamps for heating vessels externally, for evaporating samples to dryness with minimum of spattering. Heating mantles (glass-cloth insulated) acceptable where visibility unimportant, contamination unlikely.

Hoods. Exhaust air filtered; at least 100 linear feet per minute of air should go into hood opening. Designed to prevent air velocity from reaching point where bench-top paper covering is disarranged.

Moving, positioning devices. For small objects behind a shield.

Ball-and-socket manipulator. Consists of appropriate tongs mounted in ball which fits into spherical socket in shielding wall; permits push-pull action plus rotational and translational motion.

Control motors. Miniature fleapower motors, commercially available; useful for positioning objects such as mirrors.

Cranes, small, and manipulators. No stock items commercially available. Can be made to order.

Fishing pole. With reel and cord. Ordinary rigid metal pole useful for handling solid sources at a distance. Reel capable of locking in given position. Nylon cord advisable—strong, hangs straight without twisting. Small stainless-steel basket or weighted (not barbed or pointed) hook may be hung on end of line.

Flexible cable. Simple means of transmitting both rotational and translational motion behind shield; impractical to use very long cable or to have more than two or three bends.

Magnets. Permanent magnet on end of long pole or string useful in retrieving sources which have fallen into otherwise unaccessible places behind shield. Electromagnet suspended by wires from pole useful for picking up and laying down cobalt sources of any size or shape; alternating current used to prevent leaving residual magnetism in source.

Pneumatic, hydraulic cylinders. Stationary cylinder, movable piston actuated by air or liquid pressure; for translational motion of source, equipment, or heavy shielding doors. For precise positioning of small objects, device, improvised from two hypodermic syringes (needles removed) connected by

length of stiff hose, useful. Whole assembly filled with oil; movement of one plunger causes other to move corresponding amount.

Pneumatic tubes. Commercially available; similar to those used by some department stores; operate on air pressure or vacuum. For rapid transfer of source or detecting device between two fixed points.

Servomotors. Motor-generator combination; neat way of transmitting precisely rotational motion through shield. Systems available which transmit large torques with negligible angular lag between generator and motor.

Needles. Gold-plated cobalt needles for insertion into animals or human patients for local or internal irradiation; made and plated before activation in pile.

Optical viewing equipment.

Binoculars. Ordinary type—6 × 30 or 7 × 50. Useful for viewing objects at a distance either directly or through mirrors.

Mirrors. Indispensable for work involving shields; good grade of plate glass recommended to permit observation of small details with aid of binoculars.

Periscopes. Preferred for operations requiring a considerable amount of close-up viewing behind a shield. Usually built to customer's specifications; can sometimes be assembled from war-surplus equipment such as drift sights, gun sights, etc.

Pumps. Useful device for small-scale pumping of liquids is wheel with rollers around periphery mounted so that they squeeze piece of plastic or rubber tubing. When wheel rotates, rollers force slugs of liquid through tube ahead of them. Diaphragm and bellows pumps used for larger scale.

Sealing equipment. Glass vials containing powdered sources sealed off by mounting unsealed vial—previously constricted at point to be sealed—in chuck which can be rotated slowly (flexible shaft, motor, etc.). Lighted glassblower's torch brought up to constriction; vacuum applied to open end of tubing. When sealed, vial's weight pulls it apart; it falls into dish of sand to cool.

Sintered glass disks. For liquid filtering. Useful vessel (patent pending) has disk sealed in bottom; liquids retained above disk by current of air blown up through disk; particularly adaptable to remotely controlled chemical operations in closed systems.

Stirrers, magnetic. Glass-covered soft-iron stirrer, rotated by external rotating magnet; useful for closed systems on nonviscous liquids.

Tools for opening.

Glass vials. Opened at distance by means of burr or small abrasive wheel mounted on small portable motor or on end of flexible shaft; safer than most other methods.

Metal cans. Pipe or tubing cutter easily adapted to remote operation; rotated by one end held in collet, other end cut off by cutter held stationary against it.

Transporting, lifting heavy equipment. Cranes, monorails, dollies, lift trucks often necessary, for although shield weighing 150 lb adequate for small 1-c source, often only available shield is heavier. One battery-driven lift truck commercially available is easily adapted to remote operation.

Waste containers.

Trash cans. Foot-operated cover with removable inner can preferred; paper bags coated with polyethylene also very good as liners.

"Hot pot." Container for liquid waste too active to be discharged into sewer; mild steel can with polyethylene liner recommended.

INSTRUMENTS

Personnel monitoring.

Film badges. Small metal frames holding X-ray film; clip to clothing; useful range 30 mr to 2.5 r.

Finger rings. Plastic rings containing X-ray film; useful range 200 mr to 50 r.

Pocket chambers. Small ionization chambers clip to clothing. Given standard electrostatic charge before wearing; residual charge read on electroscope—difference proportional to amount of radiation received by wearer.

Self-reading pocket chambers. Miniature electroscopes clip to clothing; when held to light can be read directly; useful range 0–200 mr. Convenient.

Wrist bands. Film badges held on wrist by spring-type wrist-watch bands.

Hand and foot counters. Multiple G-M tubes wired to count palms, backs of both hands, bottoms of feet simultaneously.

Survey instruments.

Probes, friskers. G-M tubes connected to scaling circuit by long flexible-lead wires.

Ionization chambers, portable. Direct-reading; self contained; standard range required.

R-meters. Similar in principal to pocket chambers; sizes up to 10 r required.

Counting equipment, accessories. All items listed here are standard ones required for any counting work and are listed for completeness only.

Scaler.

G-M tube.

Mount. For holding G-M tube and samples at fixed geometry.

Shield, G-M tube. To reduce background.

Standard reference sample.

Absorbers. Lead, aluminum, in sets.

Counting cards. Plain, or with hole punched in center.

Watch glasses. For evaporated samples.

Planchets. For evaporated samples.

Cellophane. For covering samples.

Zapon lacquer. For covering samples.

Scotch tape. For mounting samples.

Small Hirsch funnels. For preparing samples.

Small filter paper circles. To fit Hirsch funnels.

Laboratory Equipment • 1 mc—1 c, β-emitter

By MYRON B. HAWKINS

Naval Radiological Defense Laboratory
San Francisco, California

THE USE OF P^{32} as a research or clinical tool imposes certain precautionary measures upon a laboratory. These are determined by the isotope's physical, chemical, and radiation characteristics.

Only beta particles, with a maximum energy of 1.69 Mev, are emitted by P^{32}. But shielding is required to completely absorb these radiations. As an indication of the necessity of shielding, Tompkins* has reported that 5 mc of P^{32} produces the following radiation fields: 4 r/hr at 5 in. over the top of an open beaker with the dample dry; 1.2 r/hr at contact through the bottom of the beaker; and 60 mr/hr 8 in. from the sides of the beaker. With the sample dissolved in 10 ml of 6*N* HCl, the corresponding readings are reduced to 1 r/hr, 275 mr/hr, and 7 mr/hr. Obviously, because of the unpredictable dosage rates under various conditions, shielding of at least range thickness should be used wherever possible.

The half-life of radioactive material is another characteristic that affects handling equipment and techniques In the case of P^{32}, the half-life is 14.3 days. Decontamination of equipment, for instance, may be done economically (from some standpoints) by storing the equipment until the contamination has died to a permissible level. The same procedure may be used for radioactive waste. Whether this method is used for P^{32} or not is dependent on certain economic factors, such as labor cost, amount of equipment on hand, availability of storage space, etc., that can be determined only by an analysis of the conditions in the specific laboratory.

Other precautions, due to the possibility of contamination, are dependent largely upon the chemical and physical form of the radioisotope used, and to the operations performed upon it. In most cases, the inadvisability of cross contaminating the experimental material (so-called "technical contamination") far exceeds the health hazards of general contamination to personnel. Consequently, the possibility of any amount of air, furniture, equipment or personnel contamination must be held to a minimum. Physical segregation of different levels of activity with their atttendant apparatus and equipment is of prime importance.

* P. C. Tompkins, MDDC 1527 (1947).

MATERIALS

Cleaning reagents. Detergents, cleaning solution, etc. For cleaning glassware, general decontamination, etc.

Film, photographic. For radioautography. Commercial "fast" film.

Plastics.

Casting and molding. For radioautography. Specimen mounting.

Casting and commercial forms. For shielding. Should be about ¾ in. thick

for P^{32}. Can be machined to fit glassware, other apparatus. Sheets used to fabricate boxes, other enclosures.

APPARATUS

Absorbers. Should be plastic, aluminum, or other low atomic number material. Note that P^{32} betas have range in aluminum of 800 mg/cm², half thickness of 100 mg/cm².

Animal cages. Stainless-steel or painted cages preferred from decontamination standpoint.

Burette, dispensing. Standard automatic burette modified to reduce hold-up; can be cleaned without dismantling.

Centrifuges. Should be painted for corrosion resistance.

Glassware. Commercial usable for many applications. Special apparatus desirable for remote control if excessive dosage rates anticipated.

Glove boxes. Should be used when contamination is possible. Should be painted. Flow rate 2–5 ft³/min for box about $1\frac{1}{2} \times 2 \times 3$ ft.

Hoods, chemical. Painted for corrosion resistance. Joints and cracks taped. Flow rates should conform to AEC regulations (100–150 linear feet per minute across face).

Microchemical equipment. Micropipettes, burettes, etc., necessary for handling micro quantities.

Mixing cylinder. Assembly combines mixing, storage, and dispensing units; operated remotely by air pressure. Not available commercially (P. C. Tompkins, A. Briodo, J. D. Teresi, MDDC-377, 1947).

Pipettors, remote. For transfer of liquids when dosage rates are excessive.

Precipitator, Stang. Special unit for precipitation, filtering, etc.; controlled remotely by air pressure or vacuum.

Reference sources. Required for calibration of instruments.

Shielding. Plastic or aluminum at least as thick as sample trays below. Material with atomic number greater than aluminum to be avoided because of greater production of Bremsstrahlung.

Syringes. For injections. Should be remote control or sheathed to reduce dosage.

Tongs. To handle all containers of P^{32} when sufficient shields are not provided.

Trays, sample. Should be constructed of material of sufficient thickness for complete absorption of P^{32} betas. ($\frac{1}{8}$ in. aluminum; $\frac{3}{8}$ in. plastic).

Tweezers. To handle counting samples.

Waste containers.

Can type. Should be foot operated with disposable-type bag.

Cartons, ice cream. Disposable, bench-top waste containers.

Paper bags. Disposable containers for dry waste.

INSTRUMENTS

Assay instruments. Window thickness of tube should be about 4 mg/cm² or less.

Counting shields. To reduce background error. Should be lined with aluminum.

Monitoring instruments. Wall thickness of tube should be 40 mg/cm² or less.

Laboratory Equipment • >1 c, Physical

By L. D. TURNER
Metallurgy Section, Pile Technology Division
General Electric Company, Richland, Washington

THE TESTS that have been considered for this report include all those that are common to a regular metallurgical laboratory. However, the standard test equipment must be modified to permit remote operation with adequate contamination, radiation, and ventilation control. Only those items that are in variance with standard equipment will be discussed.

The general operating philosophy that has been developed has as its main tenets: (1) an enclosed cell that will accommodate most types of tests, one at a time; (2) contamination, radiation and ventilation control as near the source as is compatible with the test; (3) manipulators that have a single purpose, such as handling the source; (4) complete mechanical or electrical operation of the equipment, and (5) easy placement and removal of any test equipment.

Materials

Hardness testing with a universal-type Rockwell tester has been selected as representative of these operating philosophies. The following list of materials are desirable for conducting this test:

1. Tank-grade ASTM A7 steel for cell material.
2. Type 347 or equal stainless steel for tongs, platforms, etc.
3. Galvanized iron for ventilating air duct to atmospheric exhaust.
4. Metallic lead in the form of wool, shot and brick.
5. Type 2S aluminum plate, sheet, rod and tubing for tongs, platforms, mechanical manipulation.
6. Plastics such as Permafil, Selectron and Bakelite for sample mounting; Krylon, Cocoon, Liquid Envelope for spray coatings.
7. Absorbent and kraft paper for easily removable contaminants.
8. Leaded glass; high density for shielded viewing.
9. Lighting: two 150-watt projector floods for general lighting and a few spot lights for specific viewing.
10. Copper; electrical conductor cable and connections. Tubing and fittings.
11. Flexible hose for ventilation.

Apparatus

The apparatus that is necessary is as follows:

1. Work cell—4 × 6 × 4 ft (interior dimensions) steel cell with 7½-in. diameter, stepped holes at frequent intervals to permit using the same cell for other physical tests. The walls must be sufficiently thick to accommodate the desired radiation or contamination level. Sides and top of cell are removable for set-up or decontamination. Ventilation air is filtered before exhausting to atmosphere.
   A. Cell services
      a. Electrical—110 v a-c
      b. Viewing—leaded glass.
      c. Manipulator—to transfer sample from platform to anvil and back.
      d. Lighting—sufficient to light

cell and critical locations.

e. Ventilation—sufficient air to provide control of any airborne contaminants.

2. Decontamination cell—similar criteria as for the work cell.

3. Storage cell—an underground, rotary bin, tiered, "coke dispenser" type storage to permit complete access to any particular sample.

4. Machine shop—to maintain moderately contaminated equipment.

5. Lift truck—fork-type to place equipment in cell.

6. Pallets—to fit cell.

7. Sample transfer container—airtight aluminum can to control contamination.

8. Sample transfer container, wrench and support—to provide a safe method for opening container.

9. Cask—lead cask, stainless steel-lined, to bring sample to and from the work cell and the storage cell.

10. Hardness tester—model UTU Rockwell tester; modified for (1) electrically controlled raising and lowering of the indenter to apply and release the minor load, (2) electrically controlled movement of sample on anvil to provide any desired indent pattern, and (3) manual application and release of major load.

Furniture

The furniture that might be used would include a data recording table, electrical switch board and a stool for the operator.

Instrumentation

Instrumentation for radiation monitoring is required for personnel health monitoring and cell operation. These may be used with a Beckman amplifier to provide a suitable range in the activities encountered during the test.

Procedure

The following procedure will be used for preparing the cell, conducting the test and cleaning the cell following the test:

Cell preparation

1. The modified hardness tester is assembled on a plate of 2S aluminum and placed on the aluminum pallet. The lift truck places the equipment and pallet in the cell.

2. Areas in the cell with greatest potential for contamination are covered with a layer of kraft and a layer of absorbent paper. This, of course, does not include the anvil which must be decontaminated after the test equipment is removed.

3. A false bottom is prepared from galvanized iron for placing beneath the path of transference of the source. This will alleviate any problem created by dropping the source during transfer.

4. Flexible tubing is connected to the air exhaust and the open end placed as close to the areas of transfer and test as is possible.

5. Electrical and mechanical hookups are made to the Rockwell tester.

6. The top of the cell is fitted and suitable lighting plugs attached to provide general lighting.

7. Specific lighting is hooked up.

8. Plastic is sprayed on areas where potential contamination can occur in event of an accident.

9. The ends of the cell are then fitted and ventilation tests are made to insure contamination control.

Testing

1. The sample, in its container, is removed from storage in a cask and the cask lined up with a plug in the cell.

2. The sample container is pushed into the cell and the sample removed from its container.

3. The manipulator picks the sample up and places it on the anvil.

4. Hardness tests are made by activating the necessary electrical and mechanical motions.

5. Radiation data are also taken as the test progresses.

Cell recovery

1. The sample is returned to storage or to disposal by procedures similar to those described above.

2. Radiation survey is made before cell is opened.

3. Primary decontamination is accomplished with a manipulator which places paper and other disposable materials in a waste can.

4. The cell is opened when the primary decontamination has reduced the level of activity to a predetermined value.

5. The equipment is disconnected and removed to a secondary decontamination cell where it may be disassembled and decontaminated and re-assembled for future use.

6. The cell is completely cleaned for making other tests.

Laboratory Equipment • >1 c, Chemical

By JOHN F. GIFFORD

Engineering Section, Technical Services Division
General Electric Company, Richland, Washington

THE FACILITIES can be combined in one or two rooms for small installations. For larger installations, it is desirable to have each facility in a separate room, and, in general, clustered around the room containing the multicurie cells. In particular, the sample storage room is best located directly adjacent to one end of the multicurie cells.

In general, all rooms should have extra strong concrete floors, wide aisles and plenty of free floor area to allow convenient handling of the heavy shields and other equipment inherent in high radiation operations.

Sample Handling, Storage Room

A large bare room with protective-coated concrete floors is preferred. Sample shields may be large iron casks, placed in rows on pallets served by both hand-operated pallet trucks and a hand-operated crane. Smaller sample shields should constitute a series of interfitting cylinders of iron or lead with wall thicknesses ranging from one to three inches. This allows handling the minimum weight required for radiation shielding in each case. The doors of the cells should open directly into the storage room, with provision for remote transfer of sample shields into the cells.

The floor of this storage room can be readily cleared for cleanup or for installation of large equipment.

Equipment Assembly, Storage Room

This separate room is vitally needed to assemble and test remote equipment prior to use for "hot" work in the cells.

Decontamination Room

This facility is needed to disassemble and decontaminate remote-control apparatus after a preliminary cleanup in the cells. Besides hooded sinks it should include a completely enclosed decontamination chamber large enough to accept all laboratory equipment assemblies planned. Rubber gloves and ball-and-socket manipulators should be mounted in the walls to aid in dismantling and cleaning equipment. Full protection of personnel from contamination must be provided as well as protection from the radiation.

Machine Shop

A one-man shop containing hand tools, grinder, band saw, and lathe is essential. Again, plenty of free floor area should be provided to allow large heavy equipment to be brought into the shop on lift trucks for alteration, adjustment or repair.

Auxiliary Laboratory

Laboratory facilities are necessary for preparation of solutions and analysis of samples from the multicurie cells. A separate room is preferred for this purpose, since the radiation level directly around the cells may make eight-hour exposure of personnel undesirable.

Multicurie Cells

Form of construction. A desirable form of cell construction for both laboratory and semiworks scale of radiochemical work is a wall of steel six to thirty feet long, made up of modular panels, placed three to six feet away from a thick concrete wall. This concrete wall may be an exterior building wall, or may be a dividing wall between two cells, back to back. Horizontally rolling doors of steel form convenient end closures. The whole structure must be enclosed and provided with ventilation. During operation air should flow into all cell openings at about 150 feet per min.

For radiation levels up to about eight or ten gamma curies, the top of the cell, though hooded, need not be shielded with heavy material. Hand-operated manipulators or tongs may go freely "over-the-top" through openings at the top of the operating face just above the operators head.

For operations above ten curies, the cell top must also be shielded to absorb radiation shine, and manipulators penetrating the cell barrier must be mounted in shielding panels in the face or top.

Materials of cell construction. Cell wall construction may be of lead, concrete, or steel. If the chemical process is "frozen" and requires few and simple controls, concrete is certainly desirable because of its low cost. In the more common case requiring occasional process changes and certainly for all research and development work, very complex viewing and manipulating problems arise frequently. For such cases a face of interchangeable modular steel panels is recommended. Steel panels can be machined to close tolerances, shipped to point of use, and installed with comparative ease at a reasonable cost.

The relative density of lead and steel is particularly useful in making up manipulator and utility panels. Service piping, manipulators, etc., can be mounted in a standard hollow steel shell in such a way that when the remaining space is filled with lead, the effective shielding ability is maintained despite voids.

The inner liner of the cell can be sheet stainless steel for large unbroken surfaces, particularly the floor. In case halogens are to be used, and for cells of modular panel construction, a

strippable plastic coating is recommended. § The advantages are the ease of protecting crevices, resisting corrosion, decontamination, and making alterations.

Viewers. Viewers may be mirror systems for very simple operations and for walls no thicker than about eight inches. For concrete walls, a panel of plate glass of about the same thickness may be used. Lens systems are not desirable for general use because of high cost, complexity, and extreme inflexibility.

Cells with steel walls can take advantage of the high clarity, wide angle vision offered by the new high density (6.5) lead glass made by the Penberthy Instrument Company of Seattle, Washington. This glass has a shielding ability roughly equivalent to steel. This means that a large lead-glass panel can be mounted in an interchangeable steel modular panel frame. The whole assembly then is hardly thicker than the cell wall, and may be moved from position to position without interference with adjacent manipulator panels.

Manipulators. Manipulators can also be more flexible with steel modular panel construction. Special purpose manipulators and utility services mounted in interchangeable panels can be readily moved to any location on the cell face.

Manipulator types depend on the process involved, but, in general, a specific manipulator should be used for each specific operation. Wholly mechanical manipulators with full "feel-back" are usually most successful because of the simplicity of development, adaptation, decontamination and repair.

Flexible shafts and simple round rods are particularly useful for carrying out microscale chemistry in highly complicated assemblies. The flexible shaft offers ease of installation and alteration, combined with full "feel-back" in both thrust and rotation. The torque-distortion of the shaft gives welcome protection in the handling of delicate glassware.

In-cell equipment assemblies. Large or semiworks equipment necessarily is assembled in place in the cells. However, it can generally be so constructed that spills and other sources of cell surface contamination can be minimized by the use of pipes and valves, chutes, etc., to transfer material from vessel to vessel.

Most laboratory-scale operations however, inherently require a larger number and variety of transfer of liquids and solids. Therefore, partly for containment of contamination and partly for ease of mounting and testing complex equipment, laboratory-scale (and particularly micro-scale) equipment is better mounted in a completely enclosed wood box with a glass viewing face. Such an enclosed package can be safely removed from the "hot" cells to the decontamination room with its contained contamination, leaving the cells themselves ready for immediate re-use.

Radiation monitoring. Equipment is needed to monitor radiation and surface contamination inside the cells, and to monitor radiation, surface contamination, and airborne contamination outside the cells. A variety of commercial equipment is available for the simple cases. Considerable adaptation is necessary for manipulation of in-cell surface-contamination probes. Particularly difficult is the operation of vibration-sensitive alpha-particle probes, and equipment intended to differentiate between alpha, beta and gamma radiations.

NUCLEONICS BUYERS' GUIDE

1950–1951

An alphabetical listing of the manufacturers of equipment, materials, components and allied products used in basic research, development and applications of nuclear energy.

Every effort has been made to insure completeness and accuracy according to information supplied by the manufacturers questionnaired. Manufacturers who are advertisers in this issue are CAPITALIZED in the listings and page numbers of their advertisements shown. This makes it possible to obtain complete buying information on products quickly and easily by referring to those pages.

Compiled by the Research Staff of NUCLEONICS.

ABSORBENT PAPER

Alfax Paper & Engineering Co., 40 Riverside Ave., Brockton 27, Mass. ADV. PG. 100.
Industrial Products Engineering Co., 44–26 Hunter St., Long Island City, N. Y.
Kimberly-Clark Corp., Neenah, Wis.

ABSORBENT TISSUE

International Cellucotton Products Co., Chicago, Ill.
Kemberly-Clark Corp., Neenah, Wis.

ABSORBERS

Eagle-Picher Co., Cincinnati, Ohio
Knight, Maurice A., 171 Kelly Ave., Akron, Ohio
Nuclear Measurements Corp., 3339 Central Ave., Indianapolis, Ind. ADV. PG. 96, 97.
Nucleonic Corp. of America, 497 Union St., Brooklyn 31, N. Y.
Radiation Counter Labs., Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Struthers-Wells Corp., Warren, Pa.
Technical Associates, Inc., 3730 San Fernando Rd., Glendale 4, Calif. ADV. PG. 94.
Tracerlab, Inc., 130 High St., Boston 10, Mass. ADV. PG. 74, 75.

ACCELERATORS

Allis-Chalmers Mfg. Co., 864 S. 70th St., Milwaukee 1, Wis.
Collins Radio Co., Cedar Rapids, Iowa
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
High Voltage Engineering Corp., 7 University Rd., Cambridge 38, Mass. ADV. PG. 103.
Mullard Overseas Ltd., Century House, Shaftesbury Ave., London, W. C. 2.

ADHESIVES—Waterproof & Corrosion Proof Compounds

Aetna Plywood & Veneer Co., 1738 Elston Ave., Chicago, Ill.
Andel & Co., Inc., 5218 N. Kedzie Ave., Chicago, Ill.
Arabol Mfg. Co., 1950 16th St., San Francisco 3, Calif.
Arco Co., 7301 Bessemer Ave., Cleveland 27, Ohio
Armstrong Cork Co., 1010 Concord St., Lancaster, Pa.
Atlas Mineral Products Co., 121 Norman St., Merzman, Pa.
Beck & Sons, Inc., I., 355 E. 20th St., New York 3, N. Y.
Bishop Mfg. Corp., 254 W. 31st St., New York 1, N. Y. ADV. PG. 85.
Borden Co., Chemical Div., 350 Madison Ave., New York 17, N. Y.
Devoe & Raynolds Co., Inc., 787 First Ave., New York, N. Y.
du Pont de Nemours & Co., Inc., E. I., Wilmington 98, Del.
Electro Chemical Supply & Engineering Co., 750 Broad St., Emmaus, Pa.
General Cement Mfg. Co., 919 Taylor Ave., Rockford, Ill.
General Electric Co., Chemical Dept., Pittsfield, Mass. ADV. PGS. 65 to 72.
Goodrich Co., B. F., 448 S. Main St., Akron, Ohio
Hachmeister-Inc., 2332 Forbes St., Pittsburgh 13, Pa.
Hamilton Kent Mfg. Co., Kent, Ohio
Hollingshead Corp., R. M., Cocoon Engineering Div., 840 Cooper St., Camden, N. J.
Industrial Adhesive Co., 715 W. Davis St., Dallas, Texas
Koppers Co., Inc., Koppers Bldg., Pittsburgh 19, Pa.
Lasting Products Co., 202 S. Franklintown Rd., Baltimore 23, Md.
Linick Chemical Co., 29 E. Madison St., Chicago 2, Ill.
Mastic Tile Corp. of America, Newburgh, N. Y.
Monsanto Chemical Co., 1700 S. Second St., St. Louis 4, Mo.
Nukem Products Corp., 111 Colgate Ave., Buffalo 20, N. Y.
Paisley Products, Inc., 1770 Canalport Ave., Chicago 16, Ill.
Perkins Glue Co., 652 Gannon Ave., Lansdale, Pa.
Prufcoat Laboratories, Inc., 61 Main St., Cambridge, Mass.
Rulon Inc., Ralph V., Second & Pike Sts., Philadelphia, Pa.
Saran Protective Coatings Co., 2415 Burdette Ave., Ferndale 20, Mich.
Stonhard Co., 1306 Spring Garden St., Philadelphia 23, Pa.
Union Bay State Chemical Co., 50 Harvard St., Cambridge, Mass.
U. S. Rubber Co., Electroforming Dept., 6602 Jefferson Ave., Detroit, Mich.

ADSORPTION APPARATUS

Carbide & Carbon Chemicals Div., Union Carbide & Carbon Corp., 30 E. 42nd St., New York 17, N. Y.
Pacific Foundry Co., Ltd., 3100 19th St., San Francisco, Calif.
Pittsburgh Lectrodryer Corp., P. O. Box 1766, Pittsburgh, Pa.
Scientific Glass Apparatus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.

AGITATORS

Colloid Equipment Co., Inc., 48 Church St., New York, N. Y.
Consolidated Siphon Supply Co., Inc., 24 Wooster St., New York, N. Y.
De Vilbiss Co., 286 Phillips Ave., Toledo, Ohio
Ertel Engineering Corp., 20 Front St., Kingston, N. Y.
General Mixing Equipment Co., 411 N. 3rd St., Philadelphia, Pa.
Houston Blow Pipe & Sheet Metal Works, P. O. Box 1692, Houston 1, Texas
Industrial Products Engineering Co., 44–26 Hunter St., Long Island City, N. Y.
International Engineering, Inc., 1200 Bolander Ave., Dayton, Ohio
Mixing Equipment Co., 192 Mt. Read Blvd., Rochester 11, N. Y.
Precision Scientific Co., 3737 Cortland Ave., Chicago, Ill.
Sargent & Co., E. H., 4647 W. Foster Ave., Chicago 30, Ill.
Schutte & Koerting Co., 1254 N 12th St., Philadelphia, Pa.
Struthers-Wells Corp., Warren, Pa.

AIR CLEANERS—Electrostatic

Koppers Co., Inc., Koppers Bldg., Pittsburgh 19, Pa.
Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa.

AIR CONDITIONING EQUIPMENT

American Foundry & Furnace Co., Bloomington, Ill.
American Thermal Industries, Inc., 440 Illinois St., Detroit, Mich.
Boehm Co., John C., 1345 W. 73rd St., Cleveland 2, Ohio
Brundage Co., 502 North Park, Kalamazoo, Mich.
Buffalo Forge Co., 473 Broadway, Buffalo, N. Y.
Clarage Fan Co., 719 Porter St., Kalamazoo, Mich.
Emerson-Sack-Warner Corp., 92 Beverly, Boston, Mass.
General Controls Co., Glendale 1, Calif.
General Electric Co., Air Conditioning Dept., Bloomfield, N. J. ADV. PGS. 65 to 72.
Houston Blow Pipe & Sheet Metal Works, P. O. Box 1692, Houston 1, Texas
Marlo Coil Co., 6135 Manchester St., St. Louis, Mo.
Meyer Furnace Co., Peoria, Ill.
Mountain States Equipment Co., 1238 Speer Blvd., Denver, Colo.
Mowat Refrigerator, John, 1866 Folsom, San Francisco, Calif.
Powers Regulator Co., 2736 Greenview Ave., Chicago, Ill.
Remington Corp., 59 E. Court St., Cortland, N. Y.
Tenney Engineering Inc., 26 Avenue B, Newark 5, N. J.
Trane Co., La Crosse, Wis.
Unit Roof Ventilator Corp., 1225 W. Mitchell St., Milwaukee 4, Wis.
United States Air Conditioning Corp., Como Ave. SE at 33rd, Minneapolis 14, Minn.
Western Blower Co., 1800 Airport Way, Seattle, Wash.
Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa.
Worthington Pump & Machinery Corp., 426 Worthington Ave., Harrison, N. J.
York Corp., York, Pa.

AIR PURIFIERS

Brundage Co., 502 North Park, Kalamazoo, Mich.
De Vilbiss Co., 286 Phillips Ave., Toledo, Ohio
Houston Blow Pipe & Sheet Metal Works, P. O. Box 1692, Houston 1, Texas
Industrial Products Engineering Co., 44–26 Hunter St., Long Island City, N. Y.

Parsons Engineering Corp., 2547 E. 79th St. Cleveland, Ohio
Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa.

ALARMS—Liquid Level

See Indicators

ALARMS—Pressure

See Indicators

ALARMS—Temperature

See Indicators

ALLOYS

See Metals

AMPLIFIERS—Audio Frequency

Alden Products Co., 117 N. Main St., Brockton 64, Mass.
Allied Radio Corp., 833 W. Jackson Blvd., Chicago 7, Ill.
American Communications Corp., 306 Broadway, New York 7, N. Y.
American Electroneering Co., 2112 S. LaBrea Ave., Los Angeles, Calif.
Arlington Electric Products, Inc., 500 W. 52nd St., New York 19, N. Y.
Atomic Instrument Co., 84 Massachusetts Ave., Cambridge 39, Mass. ADV. PG. 101.
Audio Instrument Co., 133 W. 14th St., New York 11, N. Y.
Ballantine Laboratories, Inc., Boonton, N. J.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Berndt-Bach Inc., 7377 Beverly Blvd., Los Angeles 36, Calif.
Brociner-Mass Instruments Inc., 1546 Second Ave., New York 28, N. Y.
Carnine & Bitter, 2332 Ontario Rd. NW, Washington 9, D. C.
Century Geophysical Corp., P. O. Box 6216, Tulsa 10, Okla.
Chatham Electronics Corp., 475 Washington St., Newark 2, N. J.
Cinema Engineering Co., 1510 W. Verdugo Ave., Burbank, Calif.
Clarkstan Corp., 11921 SW Pico Blvd., Los Angeles 64, Calif.
Collins Audio Products Co., P. O. Box 368, Westfield, N. J.
Communication Devices Co., 2331 Twelfth Ave., New York 27, N. Y.
Consolidated Engineering Corp., 620 N. Lake Ave., Pasadena 4, Calif. ADV. PG. 82.
Coral Designs Div., Henry G. Dietz Co., 12–16 Astoria Blvd., Long Island City 2, N. Y.
Cossor (Canada) Ltd., 301 Windsor St., Halifax, N. S., Canada
Custom Craft Mfg. Co., 256 E. 98th St., Brooklyn, N. Y.
Davies Laboratories, Inc., 4705 Queensbury Rd., Riverdale, Md.
Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.
Electro-Mechanical Research, Inc., Ridgefield, Conn.
Electronic Instrument Co., Inc., 276 Newport St., Brooklyn 12, N. Y.
Electronic Workshop, Inc., 351 Bleecker St., New York 14, N. Y.
El-Tronics, Inc., 2649 No. Howard St., Philadelphia 33, Pa. ADV. PG. 76, 77.
Engineering Laboratories, Inc., 620 E. Fourth St., Tulsa 3, Okla.
Fairchild Recording Equipment Corp., 154th St. & 7th Ave., Whitestone, N. Y.

Amplifiers

Fidelity Amplifier Co., 703 Willow St., Chicago 14, Ill.
Fluke Engineering Co., Inc., Box 755, Springdale, Conn.
Freed Transformer Co., Inc., 1736 Weirfield St., Brooklyn 27, N. Y.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Furst Electronics, 20 S. Jefferson St., Chicago 6, Ill.
Gale Dorothea Mechanisms, 37–61 85th St., Jackson Heights, L. I., N. Y.
Gaveco Labs., Inc., 2 East End Ave., New York 21, N. Y.
General Electric Co., Electronics Dept., Electronics Park, Syracuse, N. Y. ADV. PGS. 65 to 72.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Hartley Co., Ltd., H. A., 152 Hammersmith Rd., London W. 6, England.
Hewlett-Packard Co., 395 Page Mill Rd., Palo Alto, Calif.
Highland Engineering Co., 32 Holman Blvd., Hicksville, N. Y.
Inductograph Laboratory, Box 76, Brookfield, Conn.
Interelectronics Corp., 2432 Grand Concourse, New York 57, N. Y.
Leland Instruments, Ltd., 22–23 Millbank, London, S. W. 1.
Lincrophone Co., Inc., 226 Lansing St., Utica, N. Y.
Loral Electronics Corp., 794 E. 140th St., New York 54, N. Y.
M. P. Concert Installations, Fairfield 10, Conn.
MacLeod & Hanopol, Inc., 10 Joiner St., Charlestown 29, Mass.
Maurer, Inc., J. A., 37–01 31st St., Long Island City, N. Y.
Millen Mfg. Co., James, 150 Exchange St., Malden, Mass.
Millivac Instruments, Box 3027, New Haven, Conn.
Minnesota Electronics Corp., 97 E. Fifth St., St. Paul 1, Minn.
Moulic Specialties Co., 1005 W. Washington St., Bloomington, Ill.
Mullard Overseas Ltd., Century House, Shaftesbury Ave., London, W. C. 2.
National Intercommunicating Systems, 1531 Devon Ave., Chicago 26, Ill.
Network Mfg. Corp., Bayonne, N. J.
Newcomb Audio Products Co., 6824 Lexington Ave., Hollywood 38, Calif.
Phoenix Precision Instrument Co., 3803 N. 5th St., Philadelphia, Pa.
Plastics & Electronics Co., 272 Northland Ave., Buffalo 8, N. Y.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Radio Corp of America, RCA Victor Div., Engineering Products Dept., Front & Cooper Sts., Camden, N. J. ADV. PG. 95.
Rauland-Borg Corp., 3523 W. Addison St., Chicago 18, Ill.
Remler Company, Ltd., 2101 Bryant St., San Francisco 10, Calif.
Sargent-Rayment Co., The, 212 Ninth St., Oakland 7, Cal.
Simpson Mfg. Co., Inc., Mark, 32–28 49th St., Long Island City 3, N. Y.
Southwestern Industrial Electronic Co., 2831 Post Oak Rd., Houston 19, Texas
Stancil-Hoffman Corp., 1016 N. Highland Ave., Hollywood, 38, Calif.
Standard Electronics Research Corp., 2 East End Ave., New York 21, N. Y.
Stephens Mfg. Corp., 8538 Warner Drive, Culver City, Calif.
Supreme, Inc., Greenwood, Miss.
Tech Laboratories, Inc., Bergen & Edsall Blvds., Palisades Park, N. J.

Amplifiers

Teletronics Laboratory, Inc., 352 Maple Ave., Westbury, N. Y.
Transmitter Equipment Mfg. Co., Inc., 345 Hudson St., New York 14, N. Y.
Triumph Mfg. Co., 913 W. Van Buren St., Chicago, Ill.
Vacuum Electronic Engineering Co., 756 Third Ave., Brooklyn 32, N. Y.
Waterman Products Co., Inc., 2445–63 Emerald St., Philadelphia 25, Pa.
Wayne-Kerr Laboratories, Ltd., New Malden, Surrey, England
Western Electro-Acoustic Labs., 204 S. Beverly Drive, Beverly Hills, Calif.
Western Sound & Electric Labs., Inc., 805 S. Fifth St., Milwaukee 4, Wis.

AMPLIFIERS—d-c

Alden Products Co., 117 N. Main St., Brockton 64, Mass.
American Communications Corp., 306 Broadway, New York 7, N. Y.
American Electroneering Co., 2112 S. LaBrea Ave., Los Angeles, Calif.
Associated Research, Inc., 3758 W. Belmont, Chicago 18, Ill.
Beckman & Whitley, Inc., 985 San Carlos Ave., San Carlos, Calif.
Collins Radio Co., Cedar Rapids, Iowa
Electro-Mechanical Research, Inc., Ridgefield, Conn.
Electronic Associates, Inc., Long Branch, N. J.
Electronic Measurements Co., Red Bank, N. J.
Electronic Tube Corp., 1200 E. Mermaid Lane, Philadelphia 18, Pa.
El-Tronics, Inc., 2649 No. Howard St., Philadelphia 33, Pa. ADV. PG. 76, 77.
Furst Electronics, 20 S. Jefferson St., Chicago 6, Ill.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Industrial Electronics, Inc., 8060 Wheeler St., Detroit 10, Mich.
Instrument Laboratories, 315 W. Walton Place, Chicago 10, Ill.
Leeds & Northrup Co., 4970 Stenton Ave., Philadelphia 44, Pa.
Liston Folb Div. Atlas Coil Winders, Inc., Stamford, Conn.
Macdonald & Co., Inc., W. S. 33 University Rd., Cambridge 38, Mass.
Millivac Instruments, Box 3027, New Haven, Conn.
Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne & Roberts Aves., Philadelphia 44, Pa. ADV. PG. 88.
Rahm Instruments Inc., 12 W. Broadway, New York 7, N. Y.
Southwestern Industrial Electronic Co., 2831 Post Oak Rd., Houston 19, Texas
Waterman Products Co., Inc., 2445–63 Emerald St., Philadelphia 25, Pa.

AMPLIFIERS—Linear

Atomic Instrument Co., 84 Massachusetts Ave., Cambridge 39, Mass. ADV. PG. 101.
Nuclear Instrument & Chemical Corp., 223 W. Erie St., Chicago 10, Ill. ADV PG. Back Cover.
Nuclear Measurements Corp., 3339 Central Ave., Indianapolis, Ind. ADV. PG. 96, 97.

AMPLIFIERS—Medical Instrument

Airlectron, Inc., P. O. Box 151, Caldwell, N. J.
Alden Products Co., 117 N. Main St., Brockton 64, Mass.
American Electroneering Co., 2112 S. LaBrea Ave., Los Angeles, Calif.
Atomic Instrument Co., 84 Massachusetts Ave., Cambridge 39, Mass. ADV. PG. 101.
Baldwin Instrument Co., Ltd., Brooklands Works, Dartford, Kent

Amplifiers

Carnine & Bitter, 2332 Ontario Rd. NW, Washington 9, D. C.
Century Geophysical Corp., P. O. Box 6216, Tulsa 10, Okla.
Cossor (Canada) Ltd., 301 Windsor St., Halifax, N. S., Canada
Custom Craft Mfg. Co., 256 E. 98th St., Brooklyn, N. Y.
Dalions Labs., 5066 Santa Monica Blvd., Los Angeles, Calif.
Edin Co., Inc., 207 Main St., Worcester, Mass.
Electro-Mechanical Research, Inc., Ridgefield, Conn.
Electronic Tube Corp., 1200 E. Mermaid Lane, Philadelphia 18, Pa.
Electronic Workshop, Inc., 351 Bleecker St., New York 14, N. Y.
Industrial Control Co., 1462 Undercliff Ave., New York 52, N. Y.
Industrial Science Associates, 542 Fifth Ave., New York 19, N. Y.
Interelectronics Corp., 2432 Grand Concourse, New York 57, N. Y.
Leeds & Northrup Co., 4970 Stenton Ave., Philadelphia 44, Pa.
Leland Instruments, Ltd., 22–23 Millbank, London, S. W. 1.
Liston Folb Div., Atlas Coil Winders, Inc., Stamford, Conn.
MacLeod & Hanopol, Inc., 10 Joiner St., Charlestown 29, Mass.
Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne & Roberts Aves., Philadelphia 44, Pa. ADV. PG. 88.
Minnesota Electronics Corp., 97 E. Fifth St., St. Paul 1, Minn.
Moulic Specialties Co., 1005 W. Washington St., Bloomington, Ill.
Phoenix Precision Instrument Co., 3803 N. 5th St., Philadelphia, Pa.
Plastics & Electronics Co., 272 Northland Ave., Buffalo 8, N. Y.
Precision Electronics, 641 Milwaukee Ave., Chicago 22, Ill.
Process & Instruments, 60 Greenpoint Ave., Brooklyn 22, N. Y.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Rahm Instruments, Inc., 12 West Broadway, New York 7, N. Y.
Sanborn Co., 39 Osborn St., Cambridge, Mass.
Southwestern Industrial Electronic Co., 2831 Post Oak Rd., Houston 19, Texas
Stephens Mfg. Corp., 8538 Warner Drive, Culver City, Calif.
Tech Laboratories, Inc., Bergen & Edsall Blvds., Palisades Park, N. J.
Waterman Products Co., Inc., 2445–63 Emerald St., Philadelphia 25, Pa.

AMPLIFIERS—r-f

Allied Radio Corp., 833 W. Jackson Blvd., Chicago 7, Ill.
American Electroneering Co., 2112 S. LaBrea Ave., Los Angeles, Calif.
Applied Science Corp. of Princeton, P. O. Box 44, Princeton, N. J.
Atomic Instrument Co., 84 Massachusetts Ave., Cambridge 39, Mass. ADV. PG. 101.
Audio Instrument Co., 133 W. 14th St., New York 11, N. Y.
Carnine & Bitter, 2332 Ontario Rd. NW, Washington 9, D. C.
Communication Devices Co., 2331 Twelfth Ave., New York 27, N. Y.
Davies Laboratories, Inc., 4705 Queensbury Rd., Riverdale, Md.
Electronic Engineering Corp., 624 Ridge Rd., Lyndhurst, N. J.

Amplifiers

Electronic Workshop, Inc., 351 Bleecker St., New York 14, N. Y.
El-Tronics, Inc., 2649 No. Howard St., Philadelphia 33, Pa. ADV. PG. 76, 77.
General Electric Co., Electronics Dept., Electronics Park, Syracuse, N. Y. ADV. PG. 65 to 72.
Hewlett-Packard Co., 395 Page Mill Rd., Palo Alto, Calif.
Inductograph Laboratory, Box 76, Brookfield, Conn.
Interelectronics Corp., 2432 Grand Concourse, New York 57, N. Y.
Leland Instruments, Ltd., 22–23 Millbank, London, S. W. 1.
Millen Mfg. Co., James, 150 Exchange St., Malden, Mass.
Millivac Instruments, Box 3027, New Haven, Conn.
Network Mfg. Corp., Bayonne, N. J.
Phoenix Precision Instrument Co., 3803 N. 5th St., Philadelphia, Pa.
Plastics & Electronics Co., 272 Northland Ave., Buffalo 8, N. Y.
Polarad Electronics Corp., 100 Metropolitan Ave., Brooklyn 11, N. Y.
Precision Electronics, 641 Milwaukee Ave., Chicago 22, Ill.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Radio Corp. of America, RCA Victor Div., Engineering Products Dept., Front & Cooper Sts., Camden, N. J. ADV. PG. 95.
Simpson Mfg. Co., Mark, 32–28 49th St., Long Island City 3, N. Y.
Spencer-Kennedy Labs, Inc., 186 Massachusetts Ave., Cambridge 39, Mass. ADV. PG. 92.
Standard Electronics Research Corp., 2 East End Ave., New York 21, N. Y.
Stephens Mfg. Corp., 8538 Warner Drive, Culver City, Calif.
Supreme, Inc., Greenwood, Miss.
Tech Laboratories, Inc., Bergen & Edsall Blvds., Palisades Park, N. J.
Teletronics Laboratory, Inc., 352 Maple Ave., Westbury, N. Y.
Television Equipment Corp., 238 William St., New York, N. Y. ADV. PG. 79.
Transmitter Equipment Mfg. Co., Inc., 345 Hudson St., New York 14, N. Y.
Waterman Products Co., Inc., 2445–63 Emerald St., Philadelphia 25, Pa.
Wayne-Kerr Laboratories, Ltd., New Malden, Surrey, England

AMPLIFIERS—Wideband

American Communications Corp., 306 Broadway, New York 7, N. Y.
American Electroneering Co., 2112 S. LaBrea Ave., Los Angeles, Calif.
Applied Science Corp. of Princeton, P. O. Box 44, Princeton, N. J.
Audio Instrument Co., 133 W. 14th St., New York 11, N. Y.
Brach Mfg. Corp., 200 Central Ave., Newark 4, N. J.
Carnine & Bitter, 2332 Ontario Rd. NW, Washington 9, D. C.
Century Geophysical Corp., P. O. Box 6216, Tulsa 10, Okla.
DuMont Laboratories, Inc., Allen B., Instrument Div., 1000 Main Ave., Clifton, N. J.
Electro-Mechanical Research, Inc., Ridgefield, Conn.
Electronic Tube Corp., 1200 E. Mermaid Lane, Philadelphia 18, Pa.
Electronic Workshop, Inc., 351 Bleecker St., New York 14, N. Y.
El-Tronics, Inc., 2649 No. Howard St., Philadelphia 33, Pa. ADV. PG. 76, 77.
Fairchild Recording Equipment Corp., 154th St. & 7th Ave., Whitestone, N. Y.
Freed Transformer Co., Inc., 1736 Weirfield St., Brooklyn 27, N. Y.

Analyzers

First Electronics, 20 S. Jefferson St., Chicago 6, Ill.
Gaveco Labs., Inc., 2 East End Ave., New York 21, N. Y.
Hartley Co., Ltd., H. A., 152 Hammersmith Rd., London, W. 6, England
Hewlett-Packard Co., 395 Page Mill Rd., Palo Alto, Calif.
Highland Engineering Co., 32 Holman Blvd., Hicksville, N. Y.
Industrial Electronics, Inc., 8060 Wheeler St., Detroit 10, Mich.
Leland Instruments, Ltd., 22–23 Millbank, London, S. W. 1.
M. P. Concert Installations, Fairfield 10, Conn.
Millen Mfg. Co., James, 150 Exchange St., Malden, Mass.
Network Mfg. Corp., Bayonne, N. J.
Nuclear Measurements Corp., 3339 Central Ave., Indianapolis, Ind. ADV. PG. 96, 97.
Phoenix Precision Instrument Co., 3803 N. 5th St., Philadelphia, Pa.
Polarad Electronics Corp., 100 Metropolitan Ave., Brooklyn 11, N. Y.
Precision Electronics, 641 Milwaukee Ave., Chicago 22, Ill.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Radioactive Products, Inc., 3201 E. Woodbridge St., Detroit 7, Mich.
Remler Company, Ltd., 2101 Bryant St., San Francisco, Calif.
Simpson Mfg. Co., Inc., Mark, 32–28 49th St., Long Island City 3, N. Y.
Southwestern Industrial Electronic Co., 2831 Post Oak Rd., Houston 19, Texas
Spencer-Kennedy Labs, Inc., 186 Massachusetts Ave., Cambridge 39, Mass. ADV. PG. 92.
Standard Electronics Research Corp., 2 East End Ave., New York 21, N. Y.
Stephens Mfg. Corp., 8538 Warner Drive, Culver City, Calif.
Supreme, Inc., Greenwood, Miss.
Tech Laboratories, Inc., Bergen & Edsall Blvds., Palisades Park, N. J.
Technology Instrument Corp., 1058 Main St., Waltham 54, Mass.
Television Equipment Corp., 238 William St., New York 7, N. Y. ADV. PG. 79.
Transmitter Equipment Mfg. Co., Inc., 345 Hudson St., New York 14, N. Y.
U. S. Electronic Co., 262 Canner St., New Haven 11, Conn.
Waterman Products Co., Inc., 2445–63 Emerald St., Philadelphia 25, Pa.
Wayne-Kerr Laboratories, Ltd., New Malden, Surrey, England

ANALYZERS—Coincidence

Atomic Instrument Co., 84 Massachusetts Ave., Cambridge 39, Mass. ADV. PG. 101.
Macdonald & Co., Inc., W. S., 33 University Rd., Cambridge 39, Mass.

ANALYZERS—Gas

American Oxygen Service Corp., 600 Essex St., Harrison, N. J.
Bailey Meter Co., 1044 Ivanhoe Rd., Cleveland 10, Ohio.
Beckman, Inc., Arnold O., 1020 Mission St., South Pasadena, Calif.
Cambridge Instrument Co., Inc., 3786 Grand Central Terminal, New York 17, N. Y.
Consolidated Engineering Corp., 620 N. Lake Ave., Pasadena 4, Calif. ADV. PG. 82.
Davis Emergency Equipment Co., Inc., 57 Halleck St., Newark, N. J.

Balances

Elmer & Amend, 635 Greenwich St., New York, N. Y.
Foxboro Co, 86 Neponset Ave., Foxboro, Mass.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Leeds & Northrup Co., 4970 Stenton Ave., Philadelphia 44, Pa.
Mine Safety Appliances Co., Braddock, Thomas & Meade Sts., Pittsburgh 8, Pa.
Perkin-Elmer Corp., Norwalk, Conn.
Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.
Process & Instruments, 60 Greenpoint Ave., Brooklyn 22, N. Y.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Sargent & Co., E. H., 4647 W. Foster Ave., Chicago 30, Ill.
Scientific Glass Apparatus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.
Vacuum Electronic Engineering Co., 756 Third Ave., Brooklyn 32, N. Y.
Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa.

APRONS

Belke Mfg. Co., 947 N. Cicero Ave., Chicago 51, Ill.
Colloid Equipment Co., Inc., 48 Church St., New York, N. Y.
Davis Emergency Equipment Co., Inc., 57 Halleck St., Newark, N. J.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Johns-Manville, 22 E. 40th St., New York 16, N. Y.
Mine Safety Appliances Co., Braddock, Thomas & Meade Sts., Pittsburgh 8, Pa.
Mullard Overseas Ltd., Century House, Shaftesbury Ave., London, W. C. 2
Scientific Glass Apparatus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.
U. S. Rubber Co., Electroforming Dept., 6602 Jefferson Ave., Detroit, Mich.

ASBESTOS—Filtering

Belke Mfg. Co., 947 N. Cicero Ave., Chicago 51, Ill.
Cellulo Co., Sandusky, Ohio
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Johns-Manville, 22 E. 40th St., New York 16, N. Y.

ASHING DISHES

Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Tracerlab, Inc., 130 High St., Boston 10, Mass. ADV. PG. 74, 75.

AUTOCLAVES

Aetna Scientific Co., Second & Spring Sts., Everett, Mass.
Blickman, Inc., S., 3100 Gregory Ave., Weehawken, N. J. ADV. PG. 2.
Buflovak Equipment Div., Blaw-Knox Co., 1578 Fillmore Ave., Buffalo, N. Y.
General Ceramics & Steatite Corp., Keasbey, N. J. ADV. PG. 92.
Whitlock Mfg. Co., 74 South St., Hartford, Conn.

BALANCES

Becker Division, Christian, Torsion Balance Co., Clifton, N. J.
Colloid Equipment Co., Inc., 48 Church St., New York, N. Y.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.

Balances

Humboldt Mfg. Co., 2016 N. Whipple, Chicago, Ill.
Scientific Glass Apparatus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.
Special Instruments Laboratory, Inc., 1003 Highland Ave., Knoxville, Tenn.
Torsion Balance Co., Clifton, N. J.
Troemner, Henry, 909 Arch St., Philadelphia, Pa.

BALANCES—Analytical

Becker Division, Christian, Torsion Balance Co., Clifton, N. J.
Central Scientific Co., 1700 Irving Park Rd., Chicago 13, Ill.
Colloid Equipment Co., Inc., 48 Church St., New York, N. Y.
Eimer & Amend, 635 Greenwich St., New York, N. Y.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Scientific Glass Apparatus Co., Inc., 99 Lakewood, Terrace, Bloomfield, N. J.
Torsion Balance Co., Clifton, N. J.
Troemner, Henry, 909 Arch St., Philadelphia, Pa.

BALANCES—Spring

Central Scientific Co., 1700 Irving Park Rd., Chicago 13, Ill.
Colloid Equipment Co., Inc., 48 Church St., New York, N. Y.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Humboldt Mfg. Co., 2016 N. Whipple, Chicago, Ill.

BATHS—Constant Temperature

Central Scientific Co., 1700 Irving Park Rd., Chicago 13, Ill.
Electric Hotpack Co., Inc., 5035 Cottman Ave., Philadelphia, Pa.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Leeds & Northrup Co., 4970 Stenton Ave., Philadelphia 44, Pa.
Metal Products Corp., 48 W. 19th St., Weehawken, N. J.
Precision Scientific Co., 3737 Cortland Ave., Chicago, Ill.
Sargent & Co., E. H., 4647 W. Foster Ave., Chicago 30, Ill.
Scientific Glass Apparatus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.
Standard Electronics Research Corp., 2 East End Ave., New York 21, N. Y.
Tenney Engineering, Inc., 26 Avenue B, Newark 5, N. J.

BATTERIES

Bright Star Battery Co., 200 Crooks Ave., Clifton, N. J.
Burgess Battery Co., Battery Div., Freeport, Ill.
Interelectronics Corp., 2432 Grand Concourse, New York 57, N. Y.
Mallory & Co., Inc., P. R., 3029 E. Washington St., Indianapolis 6, Ind.
National Carbon Division, Union Carbide & Carbon Corp., 30 E. 42nd St., New York 17, N. Y.
Ray-O-Vac Co., Madison, Wisconsin.
Specialty Battery Co., Madison 4, Wisconsin.
Willard Storage Battery Co., 246 E. 131st St., Cleveland 1, Ohio.

BEARINGS—Miniature

Landis & Gyr, Inc., 104 Fifth Ave., New York 11, N. Y.
Linde Air Products Co., Unit of Union Carbide & Carbon Corp., 30 E. 42nd St., New York 17, N. Y.
Miniature Precision Bearings, Inc., Keene, N. H.

Blowers

BELLOWS

Automatic Temperature Control Co., Inc., 5200 Pulaski Ave., Philadelphia 44, Pa.
Bahn Wood Products Co., Div. Bahn Organ Co., Route 30 E, Fort Wayne, Ind.
Eastern Metals Industries, 250 W. 54th St., New York 19, N. Y.
Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.
Fisher Mfg. Co., Inc., John C., 37–29 9th St., Long Island City 4, N. Y.
Zallea Brothers, 800 Locust St., Wilmington, Del.

BENCHES

Bar-Ray Products, Inc., 209 25th St., Brooklyn, N. Y.
Bahn Wood Products Co., Div. Bahn Organ Co., Route 30 E, Fort Wayne, Ind.
Brooklyn Hospital Equipment Co., Inc., 196 Lexington Ave., New York, N. Y.
Emerson-Sack-Warner Corp., 92 Beverly, Boston, Mass.
Houston Blow Pipe & Sheet Metal Works, P. O. Box 1692 Houston 1, Texas
Lyon Metal Products, Inc., 10 Montgomery St., Aurora, Ill.
Ornamental Iron Works Co., 250 E. Crosier St., Akron, Ohio.
Pressteel Co., W. Garvey & Humboldt Ave., E. Monte, Calif.

BLOWERS—Laboratory

Air Controls Inc., 2312 Superior Ave., Cleveland 14, Ohio
American Machine Products Co., Marshalltown, Iowa
Central Scientific Co., 1700 Irving Park Rd., Chicago 13, Ill.
Century Fan & Ventilating Co., 47 Cedar St., Stamford, Conn.
Clarage Fan Co., 719 Porter St., Kalamazoo, Mich.
Commercialaire, Inc., 302 Pacific St., Brooklyn 2, N. Y.
Dayton Electric Mfg. Co., 748 W. Adams, Chicago, Ill.
Eberbach & Son Co., Inc., Ann Arbor, Mich.
Eclipse Fuel Engineering Co., 705 S. Main St., Rockford, Ill.
Electric Blower Co., 350 Atlantic Ave., Boston, Mass.
Electrovent Fan & Mfg. Co., 812 W. Lake St., Chicago 7, Ill.
Fisher Mfg. Co., Inc., John C., 37–29 9th St., Long Island City, 4, N. Y.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Houston Blow Pipe & Sheet Metal Works, P. O. Box 1692, Houston 1, Texas
Ilg Electric Ventilating Co., 2850 N. Crawford Ave., Chicago 41, Ill.
International Engineering, Inc., 1200 Bolander Ave., Dayton, Ohio.
Jay Mfg. Co., Oliver Bldg., Pittsburgh 22, Pa.
Mountain States Equipment Co., 1238 Speer Blvd., Denver, Colo.
Precision Scientific Co., 3737 Cortland Ave., Chicago, Ill.
Small Motors, Inc., 2076 Elston Ave., Chicago 14, Ill.
Stromes Systems, Inc., 22nd St. & Sixth Ave., New York, N. Y.
Sutorbilt Corp., Sutorbilt Bldg., 2008 E. Slauson Ave., Los Angeles, Calif.
Unit Roof Ventilator Corp., 1225 W. Mitchell St., Milwaukee 4, Wis.
United Blower Co., Inc., 193 Center St., New York, N. Y.
United States Air Conditioning Corp., Como Ave. SE at 33rd, Minneapolis 14, Minn.

Blowers

Western Blower Co., 1800 Airport Way, Seattle, Wash.

BLOWERS—Small

Air Controls Inc., 2312 Superior Ave., Cleveland 14, Ohio.
American Machine Products Co., Marshalltown, Iowa
Breuer Electric Mfg. Co., 5100 N. Ravenswood Ave., Chicago 40, Ill.
Buffalo Forge Co., 473 Broadway, Buffalo, N. Y.
Century Fan & Ventilating Co., 47 Cedar St., Stamford, Conn.
Clarage Fan Co., 719 Porter St., Kalamazoo, Mich.
Commercialaire, Inc., 302 Pacific St., Brooklyn 2, N. Y.
Dayton Electric Mfg. Co., 748 W. Adams, Chicago, Ill.
Eclipse Fuel Engineering Co., 705 S. Main St., Rockford, Ill.
Electric Blower Co., 350 Atlantic Ave., Boston, Mass.
Electrovent Fan & Mfg. Co., 812 W. Lake St., Chicago 7, Ill.
Fairchild Camera & Instrument Corp., 88–06 Van Wyck Blvd., Jamaica 1, N. Y.
Fisher Mfg. Co., Inc., John C., 37–29 9th St., Long Island City, 4, N. Y.
General Blower Co., Inc., 6137 Market St., Philadelphia 39, Pa.
Houston Blow Pipe & Sheet Metal Works, P. O. Box 1692, Houston 1, Texas
Ilg Electric Ventilating Co., 2850 N. Crawford Ave., Chicago 41, Ill.
Industrial Products Engineering Co., 44–26 Hunter St., Long Island City, N. Y.
Jacksonville Blow Pipe Co., Jacksonville, Fla.
Joy Mfg. Co., Oliver Bldg., Pittsburgh 22, Pa.
Kruger & Blind Co., 511 Master St, Philadelphia, Pa.
Lehigh Fan & Blower Co., Allentown, Pa.
Martindale Electric Co., Hird Ave., Cleveland 7, Ohio
Mine Safety Appliances Co., Braddock, Thomas & Meade Sts., Pittsburgh 8, Pa.
Mountain States Equipment Co., 1238 Speer Blvd., Denver, Colo.
Perkins Marine Lamp & Hardware Corp., 1943 Pitkin Ave., Brooklyn, N. Y.
Rotron Mfg. Co., Inc., 7 Schoonmaker Lane, Woodstock, N. Y.
Sawyer Bailey Corp., P. O. Box 247, Station F, Buffalo 12, N. Y.
Small Motors, Inc., 2076 Elston Ave., Chicago 14, Ill.
Stromes Systems, Inc., 22nd St. & Sixth Ave., New York, N. Y.
Sutorbilt Corp., Sutorbilt Bldg., 2008 E. Slauson Ave., Los Angeles, Calif.
United Blower Co., Inc., 193 Center St., New York, N. Y.
United States Air Conditioning Corp., Como Ave. SE at 33rd, Minneapolis 14, Minn.
Western Blower Co., 1800 Airport Way, Seattle, Wash.

BOOKS

See Technical Books–Publishers

BOTTLES—Hard Rubber

Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Luzerne Rubber Co., Dewey St., Trenton, N. J.
U. S. Rubber Co., Electroforming Dept., 6602 Jefferson Ave., Detroit, Mich.

BOTTLES—Stoneware

Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Knight, Maurice A., 171 Kelly Ave., Akron, Ohio

Brick

BOXES—Metal

Andel & Co., Inc., 5218 N. Kedzie Ave., Chicago, Ill.
Bar-Ray Products, Inc., 209 25th St., Brooklyn, N. Y.
Bay Metal Products, 1557 W. Indiana Ave., Philadelphia, Pa.
Bristol Metal Products Corp., Bristol, Tenn.
Carnine & Bitter, 2332 Ontario Rd., NW, Washington 9, D. C.
Doehler Metal Furniture Co., Inc., 194 Lexington Ave., New York, N. Y.
Durlach Can & Iron Works, 168—7th, Brooklyn, N. Y.
Emerson-Sack-Warner Corp., 92 Beverly, Boston, Mass.
Heldor Bushing & Terminal Co., Inc., P. O. Box 91, Orange, N. J.
Houston Blow Pipe & Sheet Metal Works, P. O. Box 1692, Houston 1, Texas
Ice Cooling Appliance Corp., Morrison, Ill.
Imhof, Ltd., Alfred, 112 New Oxford St., London, W. C. 1
Industrial Science Associates, 542 Fifth Ave., New York 19, N. Y.
Kolton Electric Mfg. Co., 123 New Jersey Railroad Ave., Newark 5, N. J.
Leland Instruments, Ltd., 22–23 Millbank, London, S. W. 1.
Lyon Metal Products, Inc., 10 Montgomery St., Aurora, Ill.
Modern Welding Co., Owensboro, Ky.
Ornamental Iron Work Co., 250 E. Crosier St., Akron, Ohio
Radiation Counter Laboratories, Inc., 1044 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Riedling & Olberg Metal Works, 10th & Chestnut, Chester, Pa.
Stromes Systems, Inc., 22nd St. & Sixth Ave., New York, N. Y.

BOXES—Waterproof

Carnine & Bitter, 2332 Ontario Rd. NW, Washington 9, D. C.
Durlach Can & Iron Works, 168—7th, Brooklyn, N. Y.
Emerson-Sack-Warner Corp., 92 Beverly, Boston, Mass.
Glenwood Mfg. Co., 2606 N. Fernando Blvd., Burbank, Calif.

BRACKETS

Emerson-Sack-Warner Corp., 92 Beverly, Boston, Mass.
Gaveco Labs., Inc., 2 East End Ave., New York 21, N. Y.
Hamann, William, 2723 N. 5th St., Milwaukee, Wis.
Heldor Bushing & Terminal Co., Inc., P. O. Box 91, Orange, N. J.
Houston Blow Pipe & Sheet Metal Works, P. O. Box 1692, Houston 1, Texas
Ornamental Iron Work Co., 250 E. Crosier St., Akron, Ohio

BRICK—Acid Proof

Acme Brick Co., Fort Worth 2, Texas
Atlas Mineral Products Co., 121 Norman St., Mertzman, Pa.
Cambria Clay Products Co., 800 Maple St., Oak Hill, Ohio
Ceilcote Co., Rockefeller Bldg., Cleveland, Ohio
Claycraft Co., Box 666, Columbus, Ohio
Electro Chemical Supply & Engineering Co., 750 Broad St., Emmans, Pa.
Hanley Co., Bradford, Pa.
Kraftile Co., Niles, Calif.
Knight, Maurice A., 171 Kelly Ave., Akron, Ohio
Milliken Brick Co., 2100 Montier St., Pittsburgh 21, Pa.

Brick

Mineral Wells Clay Products Co., Mineral Wells, Texas
Nukem Products Corp., 111 Colgate Ave., Buffalo 20, N. Y.
Quigley Co., Inc., 527 Fifth Ave., New York, N. Y.
Rulon Inc., Ralph V., Second & Pike Sts., Philadelphia, Pa.
Thorton Fire Brick Co., Goff Bldg., Clarksburgh, W. Va.
Toronto Fire Clay Co., Toronto, Ohio
Trinidad Brick & Tile Co., Trinidad, Colo.

BRICK—Acid Resisting

Acme Brick Co., Fort Worth 2, Texas
Atlas Mineral Products Co., 121 Norman St., Mertzman, Pa.
Cambria Clay Products Co., 800 Maple St., Oak Hill, Ohio
Ceilcote Co., Rockefeller Bldg., Cleveland, Ohio
Electro Chemical Supply & Engineering Co., 750 Broad St., Emmans, Pa.
Hanley Co., Bradford, Pa.
Knight, Maurice A., 171 Kelly Ave., Akron, Ohio
Kraftile Co., Niles, Calif.
Metropolitan Brick, Inc., Canton 2, Ohio
Milliken Brick Co., 2100 Montier St., Pittsburgh 21, Pa.
Mineral Wells Clay Products Co., Mineral Wells, Texas
Nukem Products Corp., 111 Colgate Ave., Buffalo 20, N. Y.
Quigley Co., Inc., 527 Fifth Ave., New York, N. Y.
Rulon Inc., Ralph V., Second & Pike Sts., Philadelphia, Pa.
Thorton Fire Brick Co., Goff Bldg., Clarksburg, W. Va.
Toronto Fire Clay Co, Toronto, Ohio
Trinidad Brick & Tile Co., Trinidad, Colo.
United Materials & Richmond Brick Co., Ltd., Richmond, Calif.

BRIDGES—Capacitance

Brown Electro-Measurement Corp., 4637 SE Hawthorne Blvd., Portland 15, Oregon
Cinema-Television Ltd., Worsley Bridge Rd., London, S. E. 26
Clough Brengle Co., 6014 N. Broadway, Chicago, Ill.
Cossor (Canada) Ltd., 301 Windsor St., Halifax, N. S., Canada
Electronic Instrument Co., Inc., 276 Newport St., Brooklyn 12, N. Y.
Freed Transformer Co., Inc., 1736 Weirfield St., Brooklyn 27, N. Y.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Leeds & Northrup Co., 4970 Stenton Ave., Philadelphia 44, Pa.
Leland Instruments Ltd., 22–23 Millbank, London, S. W. 1
MacLeod & Hanopol, Inc., 10 Joiner St., Charlestown 29, Mass.
Marconi Instruments, Ltd., 23–25 Beaver St., New York 4, N. Y.
Shallcross Mfg. Co., 10 Jackson Ave., Collingdale, Pa.
Southwestern Industrial Electronic Co., 2831 Post Oak Rd., Houston 19, Texas
Sylvania Electric Products, Inc., 1740 Broadway, New York 19, N. Y.
Tech Laboratories, Inc., Bergen & Edsall Blvds., Palisades Park, N. J.
Wayne-Kerr Laboratories, Ltd., New Malden, Surrey, England

BRIDGES—Electrical

Associated Research, Inc., 3758 W. Belmont, Chicago 18, Ill.

Burners

Biddle Co., James G., 1316 Arch St., Philadelphia 7, Pa.
Brown Electro-Measurement Corp., 4637 SE Hawthorne Blvd., Portland 15, Oregon
Cambridge Instrument Co., Inc., 3786 Grand Central Terminal, New York 17, N. Y.
Cinema-Television Ltd., Worsley Bridge Rd., London, S. E. 26
Clough Brengle Co., 6014 N. Broadway, Chicago, Ill.
Cossor (Canada) Ltd., 301 Windsor St., Halifax, N. S., Canada.
Doven Co., 191 Central Ave., Newark 4, N. J.
Electronic Instrument Co., Inc., 276 Newport St., Brooklyn 12, N. Y.
El-Tronics, Inc., 2649 N. Howard St., Philadelphia 33, Pa. ADV. PG. 76, 77.
Freed Transformer Co., Inc., 1736 Weirfield St., Brooklyn 27, N. Y.
Gaveco Labs., Inc., 2 East End Ave., New York 21, N. Y.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Highland Engineering Co., 32 Holman Blvd., Hicksville, N. Y.
Industrial Electronics, Inc., 8060 Wheeler St., Detroit 10, Mich.
Industrial Instruments, Inc., 17 Pollack Ave., Jersey City 5, N. J.
Leeds & Northrup Co., 4970 Stenton Ave., Philadelphia 44, Pa.
Leland Instruments, Ltd., 22–23 Millbank, London, S. W. 1
Marconi Instruments Ltd., 23–25 Beaver St., New York 4, N. Y.
Millen Mfg. Co., James, 150 Exchange St., Malden, Mass.
Mullard Overseas Ltd., Century House, Shaftesbury Ave., London, W. C. 2.
Shallcross Mfg. Co., 10 Jackson Ave., Collingdale, Pa.
Southwestern Industrial Electronic Co., 2831 Post Oak Rd., Houston 19, Texas.
Sticht Co., Inc., Herman H., 27 Park Place, New York 7, N. Y.
Tech Laboratories, Inc., Bergen & Edsall Blvds., Palisades Park, N. J.
Technology Instrument Corp., 1058 Main St., Waltham 54, Mass.
Wayne-Kerr Laboratories, Ltd., New Malden, Surrey, England

BRIDGES—Temperature

Leeds & Northrup Co., 4970 Stenton Ave., Philadelphia 44, Pa.
Shallcross Mfg. Co., 10 Jackson Ave., Collingdale, Pa.
Standard Electronics Research Corp., 2 East End Ave., New York 21, N. Y.
Thwing-Albert Instrument Co., 5351 Pulaski Ave., Philadelphia 44, Pa.
Trans-Sonics, Inc., Bedford Airport, Bedford, Mass.

BURETTES—Automatic

Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Scientific Glass Apparatus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.
Special Glass Products Co., 2 W. 33rd St., New York, N. Y.

BURNERS—Laboratory

Ambory Corp., 21320 Stephenson, Hazel Park, Mich.
Central Scientific Co., 1700 Irving Park Rd., Chicago 13, Ill.

Bushings

Eclipse Fuel Engineering Co., 705 S. Main St., Rockford, Ill.
Elmer & Amend, 635 Greenwich St., New York, N. Y.
Fisher Mfg. Co., Inc., John C., 37–29, 9th St., Long Island City 4, N. Y.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Hones, Inc., Charles A., 122 S. Grand Ave., Baldwin, N. Y.
Humboldt Mfg. Co., 2016 N. Whipple, Chicago, Ill.
Linde Air Products Co., Unit of Union Carbide & Carbon Corp., 30 E. 42nd St., New York 17, N. Y.
Litton Industries, San Carlos, Calif.
Pabst Engineering Equipment Co., Inc., Elizabeth, N. J.
Precision Scientific Co., 3737 Cortland Ave., Chicago, Ill.
Reliable Gas Products Co., 219 Third NE, Cedar Rapids, Iowa
Sargent & Co., E. H., 4647 W. Foster Ave., Chicago 30, Ill.
Stromes Systems, Inc., 22nd St. & Sixth Ave., New York, N. Y.

BUSHINGS—Hermetically Sealed

American Lava Corp., Chattanooga 5, Tenn. ADV. PG. 81.
Corning Glass Works, Corning, N. Y.
Electrical Industries, Inc., 44 Summer Ave., Newark 4, N. J.
General Ceramics & Steatite Corp., Keasbey, N. J. ADV. PG. 92.
Heldor Bushing & Terminal Co., Inc., P. O. Box 91, Orange, N. J.
Hermetic Seal Products Co., 29–37 So. 6th St., Newark 7, N. J.
Stupakoff Ceramic & Mfg. Co., Latrobe, Pa.
Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa.

BUSHINGS—Nonmetallic

American Lava Corp., Chattanooga 5, Tenn. ADV. PG. 81.
Heldor Bushing & Terminal Co., Inc., P. O. Box 91, Orange, N. J.
Hermetic Seal Products Co., 29–37 S. 6th St., Newark 7, N. J.
Imperial Bronze & Mfg. Co., Jellico, Tenn.
Laconia Corp., 37 S. 6th St., Newark 7, N. J.
U. S. Rubber Co., Electroforming Dept., 6602 Jefferson Ave., Detroit, Mich.

CABINETS—Drying

Bar-Ray Products, Inc., 209 25th St., Brooklyn, N. Y.
Blickman, Inc., S., 7900 Gregory Ave., Weehawken, N. J. ADV. PG. 2.
Bowser, Inc., Refrigeration Div., Terryville, Conn.
Bristol Metal Products Corp., Bristol, Tenn.
Cossor (Canada) Ltd., 301 Windsor St., Halifax, N. S., Canada
Cutler Metal Products Co., Camden, N. J.
Durlach Can & Iron Works, 168—7th, Brooklyn, N. Y.
Electric Hotpack Co., Inc., 5035 Cottman Ave., Philadelphia, Pa.
Emerson-Sack-Warner Corp., 92 Beverly, Boston, Mass.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Houston Blow Pipe & Sheet Metal Works, P. O. Box 1692, Houston 1, Texas
Imhof, Ltd., Alfred, 112 New Oxford St., London, W. C. 1.
Industrial Products Engineering Co, 44–26 Hunter St., Long Island City, N. Y.
Kewanee Mfg. Co., 5083 S. Center St., Adrian, Mich.

Cabinets

Metal Products Corp., 48 W. 19th St., Weehawken, N. J.
Mullard Overseas Ltd., Century House, Shaftesbury Ave., London, W. C. 2.
National Research Corp., 70 Memorial Drive., Cambridge 42, Mass.
Precision Scientific Co., 3737 Cortland Ave., Chicago, Ill.
Riedling & Olberg Metal Works, 10th & Chestnut, Chester, Pa.
Sargent & Co., E. H., 4647 W. Foster Ave., Chicago 30, Ill.
Stromes Systems, Inc., 22nd St. & Sixth Ave., New York, N. Y.
Tenney Engineering, Inc., 26 Avenue B, Newark 5, N. J.

CABINETS—Instrument

Alden Products Co., 117 N. Main St., Brockton 64, Mass.
American Optical Co., Southbridge, Mass.
American Thermal Industries, Inc., 440 Illinois St., Detroit, Mich.
Arc Radio Corp., 523 Myrtle Ave., Brooklyn, N. Y.
Blickman, Inc., S., 7900 Gregory Ave., Weehawken, N. J. ADV. PG. 2.
Bristol Metal Products Corp., Bristol, Tenn.
Brooklyn Hospital Equipment Co., Inc., 196 Lexington Ave., New York, N. Y.
Buttling-Padgett Co., Inc., 830 Whittier, New York, N. Y.
Cutler Metal Products Co., Camden, N. J.
Durlach Can & Iron Works, 168—7th, Brooklyn, N. Y.
Elm Laboratories, 18 South Broadway, Dobbs Ferry, N. Y.
Emerson-Sack-Warner Corp., 92 Beverly Boston, Mass.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Glenwood Mfg. Co., 2606 N. San Fernando Blvd., Burbank, Calif.
Imhof, Ltd., Alfred, 112 New Oxford St., London, W. C. 1.
Kewanee Mfg. Co., 5083 S. Center St., Adrian, Mich.
Leland Instruments, Ltd., 22–23 Millbank, London, S. W. 1.
Pabst Engineering Equipment Co., Inc., Elizabeth, N. J.
Pressteel Co., W. Garvey & Humboldt Ave., El Monte, Calif.
Riedling & Olberg Metal Works, 10th & Chestnut, Chester, Pa.
Tenney Engineering, Inc., 26 Avenue B, Newark 5, N. J.

CABINETS—Laboratory

American Thermal Industries, Inc., 440 Illinois St., Detroit, Mich.
Andel & Co., Inc., 5218 N. Kedzie Ave., Chicago, Ill.
Atomic Instrument Co., 84 Massachusetts Ave., Cambridge 39, Mass. ADV. PG. 101.
Blickman, Inc., S., 7900 Gregory Ave., Weehawken, N. J. ADV. PG. 2.
Bowser, Inc., Refrigeration Div., Terryville, Conn.
Bristol Metal Products Corp., Bristol, Tenn.
Brooklyn Hospital Equipment Co., Inc., 196 Lexington Ave., New York, N. Y.
Durlach Can & Iron Works, 168—7th, Brooklyn, N. Y.
Elmer & Amend, 635 Greenwich St., New York, N. Y.
Electric Hotpack Co., Inc., 5035 Cottman Ave., Philadelphia, Pa.
Emerson-Sack-Warner Corp., 92 Beverly, Boston, Mass.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.

Cages

Glenwood Mfg. Co., 2606 N. San Fernando Blvd., Burbank, Calif.
Houston Blow Pipe & Sheet Metal Works, P. O. Box 1692, Houston 1, Texas
Ice Cooling Appliance Corp., Morrison, Ill.
Kewanee Mfg. Co., 5083 S. Center St., Adrian, Mich.
Precision Scientific Co., 3737 Cortland Ave., Chicago, Ill.
Pressed & Welded Steel Products Co., Inc., 38–57 11th St., Long Island City, N. Y.
Pressteel Co., W. Garvey & Humboldt Ave., El Monte, Calif.
Riedling & Olberg Metal Works, 10th & Chestnut, Chester, Pa.
Stromes Systems, Inc., 22nd St. & Sixth Ave., New York, N. Y.
Tenney Engineering, Inc., 26 Avenue B, Newark 5, N. J.
Ward's Natural Science, 3000 Ridgewood Rd. E., Rochester, N. Y.

CAGES—Animal

Blickman, Inc., S., 7900 Gregory Ave., Weehawken, N. J. ADV. PG. 2.
Emerson-Sack-Warner Corp., 92 Beverly, Boston, Mass.
Fischer-Nelson Corp., 704 West North Ave., Milwaukee 5, Wis.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Harford Metal Products, Inc., P. O. Box 459, Aberdeen, Md.
Ornamental Iron Work Co., 250 E. Crosier St., Akron, Ohio
Riedling & Olberg Metal Works, 10th & Chestnut, Chester, Pa.
Ward's Natural Science, 3000 Ridgewood Rd. E., Rochester, N. Y.

CALORIMETERS

Consolidated Siphon Supply Co., Inc., 24 Wooster St., New York, N. Y.
Cutler-Hammer, Inc., 412 N. 12th St., Milwaukee 1, Wis.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Parr Instrument Co., Moline, Ill.
Precision Scientific Co., 3737 Cortland Ave., Chicago, Ill.
Scientific Glass Appa-atus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.

CAMERAS—Oscillograph

Du Mont Laboratories, Inc., Allen B., Instrument Div., 1000 Main Ave., Clifton, N. J.
Fairchild Camera & Instrument Corp., 88–06 Van Wyck Blvd., Jamaica 1, N. Y.
Industrial Science Associates, 542 Fifth Ave., New York 19, N. Y.
Process & Instruments, 60 Greenpoint Ave., Brooklyn 22, N. Y.
Southwestern Industrial Electronic Co., 2831 Post Oak Rd., Houston 19, Texas.

CAMERAS—Television

Arlington Electric Products, Inc., 500 W. 52nd St., New York 19, N. Y.
Cinema-Television Ltd., Worsley Bridge Rd., London, S. E. 26
Douglas Radio Labs., 176 Norfolk Ave., Boston 19, Mass.
Du Mont Laboratories, Inc., Allen B., Instrument Div., 1000 Main Ave., Clifton, N. J.
Marconi Instruments, Ltd., 23–25 Beaver St., New York 4, N. Y.

Capacitors

Pioneer Electronics Corp., 2230 Broadway, Santa Monica, Calif.
Polarad Electronics Corp., 100 Metropolitan Ave., Brooklyn 11, N. Y.
Radio Corp. of America, RCA Victor Div., Engineering Products Dept., Front & Cooper Sts., Camden, N. J. ADV. PG. 95.
Teletronics Laboratory, Inc., 352 Maple Ave., Westbury, N. Y.
Television Equipment Corp., 238 William St., New York, N. Y. ADV. PG. 79.

CAMERAS—X-Ray

Abrams Instrument Corp., 600–620 E. Schiawassee St., Lansing, Mich.
Fairchild Camera & Instrument Corp., 88–06 Van Wyck Blvd., Jamaica 1, N. Y.
Jarrell-Ash Co., 165 Newberry St., Boston 16, Mass.
Kelley-Koett Instrument Co., 936 York St., Cincinnati 14, Ohio. ADV. PG. Inside Back Cover.
Mullard Overseas Ltd., Century House, Shaftesbury Ave., London, W. C. 2.
St. John X-Ray Laboratory, Califon, N. J.

CAPACITORS

NOTE: Various types of capacitors are not indicated in this listing. Contact manufacturer for specific type (s) desired.
Aerovox Corp., 740 Belleville Ave., New Bedford, Mass.
Astron Corp., 255 Grant Ave., E. Newark, N. J.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Brown-Electro Measurement Corp., 4637 SE Hawthorne Blvd., Portland 15, Ore.
Centralab Div. of Globe-Union, Inc., 900 E. Keefe Ave., Milwaukee 1, Wis.
Condenser Products Co., 1375 N. Branch St., Chicago 22, Ill.
Cornell-Dubilier Electric Corp., South Plainfield, N. J.
Corning Glass Works, Corning, N. Y.
Dumont Electric Corp., 308 Dyckman St., New York, N. Y.
Electrical Reactance Corp., Elm St., Franklinville, N. Y.
Electro Motive Mfg. Co., Willimantic, Conn.
Electronic Instrument Co., Inc., 276 Newport St., Brooklyn 12, N. Y.
Erie Resistor Corp., 644 W. 12th St., Erie, Pa.
Filtron Co., Inc., 38–25 Bell Blvd., Bayside, L. I., N. Y.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
Glenco Corp., Metuchen, N. J.
Illinois Condenser Co., 1616 N. Throop St., Chicago, Ill.
Industrial Condenser Corp., 3243 N. California Ave., Chicago 18, Ill.
Jennings Radio Mfg. Co., 1098 E. William St., San Jose 12, Calif.
Johnson Co., E. F., Waseca, Minn.
Leeds & Northrup Co., 4970 Stenton Ave., Philadelphia 44, Pa.
Mallory & Co., Inc., P. R., 3029 E. Washington St., Indianapolis 6, Ind.
Mensurements Corp., Boonton, N. J.
Millen Mfg. Co., James, 150 Exchange St., Malden, Mass.
Monmouth Radio Laboratories, Box 159, Oakhurst, N. J.
National Co., Inc., 61 Sherman St., Malden 48, Mass.
North American Philips Co., Inc., 100 E. 42nd St., New York 17, N. Y.
Pyramid Electric Co., 155 Oxford St., Paterson, N. J.
Sangamo Electric Co., Springfield, Ill.

Carboys

Sprague Electric Co., North Adams, Mass.
Standard Coil Products Co., 2329 N. Pulaski Rd., Chicago 39, Ill.
Stupakoff Ceramic & Mfg. Co., Latrobe, Pa.
United Condenser Corp., 337 E. 139th St., New 54, N. Y.
Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa.

CARBOYS—Stoneware

Knight, Maurice A., 171 Kelly Ave., Akron, Ohio

CEMENTS—Acid Proof

Carboline Co., St. Louis, Mo.
Ceilcote Co., Rockefeller Bldg., Cleveland, Ohio
Electro Chemical Supply & Engineering Co., 750 Broad St., Emmans, Pa.

CENTRIFUGES

Elmer & Amend, 635 Greenwich St., New York, N. Y.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
International Equipment Co., 1284 Soldiers Field Rd., Boston 35, Mass.
Merco Centrifugal Co., 1045 Sansome St., San Francisco 11, Calif.
Phillips-Drucker, 2245 S. Vandeventer Ave., St. Louis, Mo.
Sargent & Co., E. H., 4647 W. Foster Ave., Chicago 30, Ill.
Specialized Instruments Corp., Belmont, Calif. ADV. PG. 102.

CENTRIFUGES—Laboratory

Central Scientific Co., 1700 Irving Park Rd., Chicago 13, Ill.
Elmer & Amend, 635 Greenwich St., New York, N. Y.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
International Equipment Co., 1284 Soldiers Field Rd., Boston 35, Mass.
Phillips-Drucker, 2245 S. Vandeventer Ave., St. Louis, Mo.
Precision Scientific Co., 3737 Cortland Ave., Chicago, Ill.
Sargent & Co., E. H., 4647 W. Foster Ave., Chicago 30, Ill.
Scientific Glass Apparatus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.

CENTRIFUGES—Micro-Chemical

Central Scientific Co., 1700 Irving Park Rd., Chicago 13, Ill.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
International Equipment Co., 1284 Soldiers Field Rd., Boston 35, Mass.
Phillips-Drucker, 2245 S. Vandeventer Ave., St. Louis, Mo.
Precision Scientific Co., 3737 Cortland Ave., Chicago, Ill.
Sargent & Co., E. H., 4647 W. Foster Ave., Chicago 30, Ill.
Scientific Glass Apparatus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.
Specialized Instruments Corp., Belmont, Calif. ADV. PG. 102.

CENTRIFUGES—Refrigerated

Bowser, Inc., Refrigeration Div., Terryville, Conn.
International Equipment Co., 1284 Soldiers Field Rd., Boston 35, Mass.
Scientific Glass Apparatus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.

Chronographs

CERAMICS

American Lava Corp., Chattanooga 5, Tenn. ADV. PG. 81.
American Mosaic & Tile Co., 33 E. Broadway, Louisville, Ky.
Centralab, Div. of Globe Union Inc., 900 E. Keefe Ave., Milwaukee 1, Wis.
General Ceramics & Steatite Corp., Keasbey, N. J. ADV. PG. 92.
Kirchberger & Co., Inc., M., 1425 37th St., Brooklyn 18, N. Y.
Lapp Insulator Co., Inc., 31 Gilbert St., Le Roy, N. Y.
Mycalex Corp. of America, 60 Clifton Blvd., Clifton, N. J.
Star Porcelain Co., 61 Muirhead Ave., Trenton, N. J.
Steward Mfg. Co., D. M., Chattanooga, Tenn.
Stupakoff Ceramic & Mfg. Co., Latrobe, Pa.
Western Gold & Platinum Works, 589 Bryant St., San Francisco, Calif.

CHAINS—Instrument

Sierra Engineering Co., 123 E. Montecito Ave., Sierra Madre, Calif.

CHAMBERS—Test

Beckman, Inc., Arnold O., 1020 Mission St., South Pasadena, Calif.
Bowser, Inc., Refrigeration Div., Terryville, Conn.
Leland Instruments, Ltd., 22–23 Millbank, London, S. W. 1.
Pressed & Welded Steel Products Co., Inc., 38–57 11th St., Long Island City, N. Y.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Tenney Engineering Inc., 26 Avenue B, Newark 5, N. J.

CHARGERS—Dosimeter

Austin Co., Special Devices Div., 19 Rector St., New York 6, N. Y.
Baldwin Instrument Co., Ltd., Brooklands Works, Dartford, Kent.
Cambridge Instrument Co., Inc., 3786 Grand Central Terminal, New York 17, N. Y.
Chatham Electronics Corp., 475 Washington St., Newark 2, N. J.
Cinema-Television Ltd., Worsley Bridge Rd., London, S. E. 26
Fleming Radio (Developments) Ltd., 18–20 Laystall St., London, E. C. 1.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
Henson Co., Fred C., 3311 E. Colorado St., Pasadena 8, Calif.
Kelley-Koett Instrument Co., 936 York St., Cincinnati 14, Ohio. Adv. PG. Inside Back Cover.
Marconi Instruments, Ltd., 23–25 Beaver St., New York 4, N. Y.
Nuclear Instrument & Chemical Corp., 223 W. Erie St., Chicago 10, Ill. ADV. PG. Back Cover.
Technical Associates, Inc., 3730 San Fernando Rd., Glendale 4, Calif. ADV. PG. 94.
Tracerlab, Inc., 130 High St., Boston 10, Mass. ADV. PG. 74, 75.

CHRONOGRAPHS—Inertialess

Airlectron, Inc., P. O. Box 151, Caldwell, N. J.
Austin Co., Special Devices Div., 19 Rector St., New York 6, N. Y.
Colloid Equipment Co., Inc., 48 Church St., New York, N. Y.
Potter Instrument Co., 115 Cutter Mill Rd., Great Neck, N. Y.

CHRONOSCOPES

American Chronoscope Corp., 316 W. First St., Mt. Vernon, N. Y.
Berkeley Scientific Co., 6th & Nevin Ave., Richmond, Calif.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Marconi Instruments, Ltd., 23–25 Beaver St., New York 4, N. Y.
Rawson Electrical Instrument Co., 114 Potter St., Cambridge 42, Mass.
Standard Electric Time Co., 89 Logan St., Springfield, Mass. ADV. PG. 86.
Sticht Co., Inc., Herman, 27 Park Place, New York 7, N. Y.

CLAMPS

Chandler & Stedman, 398 Newton St., Waltham 54, Mass.
Eimer & Amend, 635 Greenwich St., New York, N. Y.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Houston Blow Pipe & Sheet Metal Works, P. O. Box 1692, Houston 1, Texas
Humboldt Mfg. Co., 2016 N. Whipple, Chicago, Ill.
Millen Mfg. Co., James, 150 Exchange St., Malden, Mass.
Pabst Engineering Equipment Co., Inc., Elizabeth, N. J.
Precision Scientific Co., 3737 Cortland Ave., Chicago, Ill.
Sargent & Co., E. H., 4647 W. Foster Ave., Chicago 30, Ill.
Scientific Glass Apparatus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.

CLEANERS—Bottle

Cooper Co., D. C., 1467 S. Michigan Ave., Chicago, Ill.
Linick Chemical Co., 29 E. Madison St., Chicago 2, Ill.

CLEANING REAGENTS

Hachmeister Inc., 2332 Forbes St., Pittsburgh 13, Pa.
Jasonals Chemical Corp., 1085 Myrtle Ave., Brooklyn 6, N. Y.
Linick Chemical Co., 29 E. Madison St., Chicago 2, Ill.
Mastic Tile Corp. of America, Newburgh, N. Y.
Quigley Co., Inc., 527 Fifth Ave., New York, N. Y.
Reilly Tar & Chemical Corp., 1615 Merchants Bank Bldg., 11 S. Meridan St., Indianapolis, Ind.

CLOTH—Acid & Alkali Resisting

Gordon-Lacey Chemical Products Co., Inc., 57–02 48th St., Maspeth, N. Y.
Mine Safety Appliances Co., Braddock, Thomas & Meade Sts., Pittsburgh 8, Pa.
Rulon Inc., Ralph V., Second & Pike Sts., Philadelphia, Pa.

CLOTHING—Acid Proof

Atlas Mineral Products Co., 121 Norman St., Mertztown, Pa.
Belke Mfg. Co., 947 N. Cicero Ave., Chicago 51, Ill.
Davis Emergency Equipment Co., Inc., 57 Halleck St., Newark, N. J.
Devoe & Raynolds Co., Inc., 787 First Ave., New York, N. Y.
Eagle-Picher Co., Cincinnati, Ohio
Mine Safety Appliances Co., Braddock, Thomas & Meade Sts., Pittsburgh 8, Pa.

U. S. Rubber Co., Electroforming Dept. 660 Jefferson Ave., Detroit, Mich.

COATINGS—Conductive

Acheson Colloids Corp., Port Huron, Mich.
Austin Co., O. 335 Throop Ave., Brooklyn 21, N. Y.
Corning Glass Works, Corning, N. Y.
du Pont de Nemours & Co., Inc., E. I., Wilmington 98, Del.
General Cement Mfg. Co., 919 Taylor Ave., Rockford, Ill.
Gits Molding Corp., 4600 W. Huron St., Chicago 44 Ill.
Hague & Co., Alfred, 226 34th St., Brooklyn, N. Y.
Interelectronics Corp., 2432 Grand Concourse, New York 57, N. Y.
Metaplast Process Inc., 9–17 37th Ave., Long Island City 1, N. Y.
Micro-Circuits Co., New Buffalo, Mich.
Sauereisen Cements Co., Sauereisen Bldg., Pittsburgh 15, Pa.
Zophar Mills, Inc., 112–130 26th St., Brooklyn 32 N. Y.

COATINGS—Protective

Acheson Colloids Corp., Port Huron, Mich.
Arco Co., 7301 Bessemer Ave., Cleveland 27, Ohio
Belke Mfg. Co., 947 N. Cicero Ave., Chicago 51, Ill.
Bishop Mfg. Corp., 254 W. 31st St., New York 1, N. Y. ADV. PG. 86.
Biwax Corp., 3445 Howard St., Skokie, Ill.
Ceresit Waterproofing Corp., 3227 S. Shields Ave. Chicago 16, Ill.
Dow Chemical Co., Midland, Mich.
du Pont de Nemours & Co., Inc., E. I., Wilmington 98, Del.
Electro Chemical Supply & Engineering Co., 750 Broad St., Emmans, Pa.
Emerson & Cuming Co., 126 Massachusetts Ave. Boston 15, Mass.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles Calif.
General Electric Co., Chemical Dept., Pittsfield, Mass ADV. PGS. 65 to 72.
Goodrich Co., B. F., 448 S. Main St., Akron, Ohio
Gordon-Lacey Chemical Products Co., Inc., 57–02 48th St., Maspeth, N. Y.
Hamilton Kent Mfg. Co., Kent, Ohio.
Hollingshead Corp., R. M., Cocoon Engineering Div. 840 Cooper St., Camden, N. J.
Horn Co., Inc., A. C., 10th St. & 44th Ave., Long Island City 1, N. Y.
Kimberly-Clark Co., Neenah, Wis.
Knight, Maurice A., 171 Kelly Ave., Akron, Ohio.
Koppers Co., Inc., Koppers Bldg., Pittsburgh 19, Pa.
Lasting Products Co., 202 S. Franklintown Rd. Baltimore 23, Md.
Micro-Circuits Co., New Buffalo, Mich.
Monsanto Chemical Co., 1700 S. Second St., St. Louis 4, Mo.
Nucleonic Corp. of America, 497 Union St., Brooklyn 31, N. Y.
Nukem Products Corp., 111 Colgate Ave., Buffalo 20 N. Y.
Prufcoat Laboratories, Inc., 61 Main St., Cambridge Mass.
Quigley Co., Inc., 527 Fifth Ave., New York, N. Y.
Rothband & Co., W. S., Bent St., Manchester 8, England
Rulon Inc., Ralph V., Second & Pike Sts., Philadelphia, Pa.
Saran Protective Coatings Co., 2415 Burdette Ave., Ferndale 20, Mich.
Stonhard Co., 1306 Spring Garden St., Philadelphia 23, Pa.
Tufcrete Co., 554 Teachout Bldg., Des Moines 9, Iowa.
United Chromium, Inc., 100 East 42nd St., New York, N. Y.

Collectors

U. S. Rubber Co., Electroforming Dept., 6602 Jefferson Ave., Detroit, Mich.
Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa.
Zophar Mills, Inc., 112–130 26th St., Brooklyn 32, N. Y.

COLLECTORS

Aget-Detroit Co., 612 First National Bank Bldg., Ann Arbor, Mich.
Emerson-Sack-Warner Corp., 92 Beverly, Boston, Mass.
Houston Blow Pipe & Sheet Metal Works, P. O. Box 1692, Houston 1, Texas.
Industrial Products Engineering Co., 44–26 Hunter St., Long Island City, N. Y.
Jacksonville Blow Pipe Co., Jacksonville, Fla.
Mine Safety Appliances Co., Braddock, Thomas & Meade Sts., Pittsburgh 8, Pa.
Newcomb-Detroit Co., 5741 Russell St., Detroit 11, Mich.
Northern Blower Co., 6427 Barberton Ave., Cleveland 2, Ohio
Parsons Engineering Corp., 2547 E. 79th St., Cleveland, Ohio
Riedling & Olberg Metal Works, 10th & Chestnut, Chester, Pa.
Stromes Systems, Inc., 22nd St. & Sixth Ave., New York, N. Y.

COLORIMETERS

Associated Research, Inc., 3758 W. Belmont, Chicago, Ill.
Bausch & Lomb Optical Co., 635 St. Paul St., Rochester 2, N. Y.
Beckman Instruments, Inc., 820 Mission St., South Pasadena, Calif. ADV. PG. 85.
Brociner-Mass Instruments, Inc., 1546 Second Ave., New York 28, N. Y.
Coleman Instruments, Inc., Maywood, Ill.
Eimer & Amend, 635 Greenwich St., New York, N. Y.
Ess Instrument Corp., 98 S. Washington St., Bergenfield, N. J.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Heincke Instrument Corp., 315 Alexander St., Rochester 4, N. Y.
Jarrell-Ash Co., 165 Neuberry St., Boston 16, Mass.
Leitz, Inc., E., 314 Hudson St., New York 13, N. Y. ADV. PG. 93.
Photobell Company, 116 Nassau St., New York 7, N. Y.
Photovolt Corp., Madison Ave., New York 16, N. Y. ADV. PG. 104.
Scientific Glass Apparatus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.

COLUMNS—Absorption

Frese Corp., Adolf, 116 W. 17 St., Los Angeles, Calif.
Houston Blow Pipe & Sheet Metal Works, P. O. Box 1692, Houston 1, Texas
Knight, Maurice A., 171 Kelly Ave., Akron, Ohio
Leader Iron Works, Inc., 2110 North Jasper, Decatur, Ill.
Oat & Sons, Inc., Joseph, Broad & Quarry Sts., Philadelphia, Pa.
Pabst Engineering Equipment Co., Inc., Elizabeth, N. J.
Scientific Glass Apparatus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.
Struthers-Wells Corp., Warren, Pa.

Containers

COLUMNS—Distilling, Fractionating, etc.

American Copper & Brass Works, Cincinnati, Ohio
Brighton Copper Works, Inc., 2146 Colerain Ave., Cincinnati, Ohio
Carnine & Bitter, 2332 Ontario Rd. NW, Washington 9, D. C.
Emerson-Sack-Warner Corp., 92 Beverly, Boston, Mass.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Glass Engineering Laboratories, Belmont, Calif.
Graver Tank & Mfg. Co., Inc., 6300 Todd Ave., East Chicago, Ill.
Houston Blow Pipe & Sheet Metal Works, P. O. Box 1692, Houston 1, Texas
Knight, Maurice A., 171 Kelly Ave., Akron, Ohio
Leader Iron Works, Inc., 2110 North Jasper, Decatur, Ill.
Oat & Sons, Inc., Joseph, Broad & Quarry Sts., Philadelphia, Pa.
Pabst Engineering Equipment Co., Inc., Elizabeth, N. J.
Scientific Glass Apparatus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.
Struthers-Wells Corp., Warren, Pa.

COMPRESSORS

Allis-Chalmers Mfg. Co., 864 S. 70th St., Milwaukee 1, Wis.
Beach-Russ Co., 44 Church St., New York 7, N. Y.
Buckeye Air Compressor Co., 414 Littell Ave., Dayton, Ohio
Clark Bros. Co., Inc., Lincoln Ave. & Fifth St., Olean, N. Y.
Decora Mfg. Co., Emeryville, Calif.
De Vilbiss Co., 296 Phillips Ave., Toledo, Ohio
Fisher Mfg. Co., Inc., John C., 37–29 9th St., Long Island City 4, N. Y.
Harris, Inc., Machine Works, 61 S. E. Yamhill, Portland, Ore.
Joy Mfg. Co., Oliver Bldg., Pittsburgh 22, Pa.
Kahlenberg Bros. Co., 12th & Monroe Sts., Two Rivers, Wis.
Keystone Compressor Co., 8417 Hagerman St., Philadelphia 36, Pa.
M. C. Mfg. Co., Lake Orion, Mich.
Master Mfg. Co., 813 W. Cabrini St., Chicago, Ill.
Mowat Refrigerator, John, 1866 Folsom St., San Francisco, Calif.
Reynolds Mfg. Co., Springfield, Mo.
Sawyer Bailey Corp., P. O. Box 247, Station F, Buffalo 12, N. Y.
Trane Co., La Crosse, Wis.
Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa.
Wilson, K. R., 215 Main St., Buffalo 3, N. Y.
Worthington Pump & Machinery Corp., 426 Worthington Ave., Harrison, N. J.

CONTAINERS—Acid Proof

Nukem Products Corp., 111 Colgate Ave., Buffalo 20, N. Y.

CONTAINERS—Glass

Armstrong Cork Co., 1010 Concord St., Lancaster, Pa.
Corning Glass Works, Corning, N. Y.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Scientific Glass Apparatus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.
Special Glass Products Co., 2 W. 33rd St., New York, N. Y.

Containers

CONTAINERS—Glass Lined

Pfaudler Co., East Ave. & Clark St., Rochester, N. Y.

CONTAINERS—Lead Lined

Andel & Co., Inc., 5218 N. Kedzie Ave., Chicago, Ill.
Atomic Instrument Co., 84 Massachusetts Ave., Cambridge 39, Mass. ADV. PG. 101.
Bar-Ray Products, Inc., 209 25th St., Brooklyn, N. Y.
Cooper Co., D. C., 1467 S. Michigan Ave., Chicago, Ill.
Graver Tank & Mfg. Co., Inc., 6300 Todd Ave., East Chicago, Ill.
Houston Blow Pipe & Sheet Metal Works, P. O. Box 1692, Houston 1, Texas
Metal Products Corp., 48 W. 19th St., Weehawken, N. J.
Nuclear Instrument & Chemical Corp., 223 W. Erie St., Chicago 10, Ill. ADV. PG. Back Cover.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
St. John X-Ray Laboratory, Califon, N. J.
Technical Associates, Inc., 3730 San Fernando Rd., Glendale 4, Calif. ADV. PG. 94.
Tracerlab, Inc., 130 High St., Boston 10, Mass. ADV. PG. 74, 75.

CONTAINERS—Metal

Aluminum Co. of America, 2156 Gulf Bldg., Pittsburgh, Pa.
Bristol Metal Products Corp., Bristol, Tenn.
Consolidated Siphon Supply Co., 24 Wooster St., New York, N. Y.
Cutler Metal Products Co., Camden, N. J.
Durlach Can & Iron Works, 168—7th, Brooklyn, N. Y.
Eclipse Fuel Engineering Co., 705 S. Main St., Rockford, Ill.
Emerson-Sack-Warner Corp., 92 Beverly, Boston, Mass.
General Mixing Equipment Co., 411 N. 3rd St., Philadelphia, Pa.
Graver Tank & Mfg. Co., Inc., 6300 Todd Ave., East Chicago, Ind.
Heldor Bushing & Terminal Co., Inc., P. O. Box 91, Orange, N. J.
Houston Blow Pipe & Sheet Metal Works, P. O. Box 1692, Houston 1, Texas
Ice Cooling Appliance Corp., Morrison, Ill.
Kaiser Aluminum Chemical Sales, Inc., 1924 Broadway, Oakland 12, Calif.
Kling Metal Spinning Co., 174 Centre St., New York 13, N. Y.
Linde Air Products Co., Unit of Union Carbide & Carbon Corp., 30 E. 42nd St., New York 17, N. Y.
Metal Products Corp., 48 W. 19th St., Weehawken, N. J.
Metalsmiths, 567 White St., Orange, N. J.
Modern Welding Co., Owensboro, Ky.
Old Dominion Iron & Steel Corp., Ball Isle, Richmond, Va.
Pressed & Welded Steel Products Co., Inc., 38–57 11th St., Long Island City, N. Y.
Riedling & Olberg Metal Works, 10th & Chestnut, Chester, Pa.

CONTAINERS—Paper

Canister Co., Inc., Phillipsburg, N. J.
Tarshis Co., N. L., 1133 Broadway, New York, N. Y.
Thomas Fibre Products Co., Syracuse, N. Y.

CONTROLS—Chemical

Associated Valve & Engineering Co., 1150 W. Marquette Rd., Chicago 21, Ill.
Austin Co., Special Devices Div., 19 Rector St., New York 6, N. Y.
Colloid Equipment Co., Inc., 48 Church St., New York, N. Y.

Controls

Foxboro Co., 86 Neponset Ave., Foxboro, Mass.
Industrial Instruments Inc., 17 Pollack Ave., Jersey City 5, N. J.
Infilco, Inc., P. O. Box 5033, Tucson, Ariz.
Leeds & Northrup Co., 4970 Stenton Ave., Philadelphia 44, Pa.
Minneapolis-Honeywell Regulator Co., Industrial Div. Wayne & Roberts Aves., Philadelphia 44, Pa. ADV. PG. 88.
Mullard Overseas Ltd., Century House, Shaftesbury Ave., London, W. C. 2.

CONTROLS—Counting & Sorting

Airlectron, Inc., P. O. Box 151, Caldwell, N. J.
Austin Co., Special Devices Div., 19 Rector St., New York 6, N. Y.
Automatic Temperature Control Co., Inc., 5206 Pulaski Ave., Philadelphia 44, Pa.
Berkeley Scientific Co., 6th & Nevin Ave., Richmond, Calif.
Berkshire Laboratories, P. O. Box 70, Concord, Mass.
Carnine & Bitter, 2332 Ontario Rd. NW, Washington 9, D. C.
Custom Craft Mfg. Co., 256 E. 98th St., Brooklyn, N. Y.
El-Tronics, Inc., 2649 No. Howard St., Philadelphia 33, Pa. ADV. PG. 76, 77.
Fielden Instrument Corp., 2920 N. 4th St., Philadelphia 33, Pa.
Industrial Electronics, Inc., 8060 Wheeler Ave., Detroit 10, Mich.
Leland Instruments, Ltd., 22–23 Millbank, London S. W. 1.
Phoenix Precision Instrument Co., 3803 N. 5th St., Philadelphia, Pa.
Photobell Company, 116 Nassau St., New York 7, N. Y.
Potter Instrument Co., 115 Cutter Mill Rd., Great Neck, N. Y.
Special Instruments Laboratory, Inc., 1003 Highland Ave., Knoxville, Tenn. ADV. PG. 91.
Standard Electronics Research Corp., 2 East End Ave., New York 21, N. Y.
Teletronics Laboratory, Inc., 352 Maple Ave., Westbury, N. Y.
Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa.

CONTROLS—Film Thickness

Austin Co., Special Devices Div., 19 Rector St., New York 6, N. Y.
Automatic Temperature Control Co., Inc., 5206 Pulaski Ave., Philadelphia 44, Pa.
Engineering Laboratories, Inc., 620 E. Fourth St., Tulsa 3, Okla.
Fielden Instrument Corp., 2920 N. 4th St., Philadelphia 33, Pa.
Foxboro Co., 86 Neponset Ave., Foxboro, Mass.
Industrial Electronics, Inc., 8060 Wheeler St., Detroit 10, Mich.
Marconi Instruments, Ltd., 23–25 Beaver St., New York 4, N. Y.
Phoenix Precision Instrument Co., 3803 N. 5th St., Philadelphia, Pa.
Standard Electronics Research Corp., 2 East End Ave., New York 21, N. Y.

CONTROLS—Fluid

Master's Inc., W. Irvin, Victor Pl. & N. Lake St., Burbank, Calif.

CONTROLS—Fluid Flow

Alloy Steel Products Co., 1500 W. Elizabeth Ave., Linden, N. J.
Associated Valve & Engineering Co., 1150 W. Marquette Rd., Chicago 21, Ill.

Controls

Austin Co., Special Devices Div., 19 Rector St., New York 6, N. Y.
Bailey Meter Co., 1044 Ivanhoe Rd., Cleveland 10, Ohio.
Baldwin Instrument Co., Ltd., Brooklands Works, Dartford, Kent
Birch Mfg. Co., 1521 Segwick St., Chicago, Ill.
Carnine & Bitter, 2332 Ontario Rd. NW, Washington 9, D. C.
Coral Designs Div., Henry G. Dietz Co., 12–16 Astoria Blvd., Long Island City 2, N. Y.
Cutler-Hammer, Inc., 412 N. 12th St., Milwaukee 1, Wis.
Engineering Laboratories, Inc., 620 E. Fourth St., Tulsa 3, Okla.
Fielden Instrument Corp., 2920 N. 4th St., Philadelphia 33, Pa.
Fischer & Porter Co., 50 County Line Rd., Hatboro, Pa.
Foxboro Co., 86 Neponset Ave., Foxboro, Mass.
General Controls Co., Glendale 1, Calif.
Infilco, Inc., P. O. Box 5033, Tucson, Ariz.
Kieley & Mueller, Inc., North Bergen, N. J.
Klipfel Mfg. Co., Weller & Zimmerman Aves., Hamilton, Ohio
Leahy Mfg. Co., East 8th & Alameda, Los Angeles 21, Calif.
Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne & Roberts Aves., Philadelphia 44, Pa. ADV. PG. 88.
Mullard Overseas Ltd., Century House, Shaftesbury Ave., London, W. C. 2.
Phoenix Precision Instrument Co., 3803 N. 5th St., Philadelphia, Pa.
Precision Scientific Co., 3737 Cortland Ave., Chicago, Ill.
Servo-Tek Products Co., 4 Godwin Ave., Paterson 1, N. J.
Taylor Instrument Co., 95 Ames St., Rochester, N. Y.
Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa.

CONTROLS—Humidity

Austin Co., Special Devices Div., 19 Rector St., New York 6, N. Y.
Bowser, Inc., Refrigeration Div., Terryville, Conn.
Colloid Equipment Co., Inc., 48 Church St., New York, N. Y.
Fielden Instrument Corp., 2920 N. 4th St., Philadelphia 33, Pa.
Foxboro Co., 86 Neponset Ave., Foxboro, Mass.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
General Controls Co., Glendale 1, Calif.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
Hoppe Engineering Co., 1 High, Greensboro, Ind.
Industrial Controls, Inc., 525 N. Noble St., Chicago 22, Ill.
Leeds & Northrup Co., 4970 Stenton Ave., Philadelphia 44, Pa.
Minneapolis-Honeywell Regulator Co., 2753 Fourth Ave., S., Minneapolis, Minn.
Photobell Company, 116 Nassau St., New York 7, N. Y.
Powers Regulator Co., 2736 Greenview Ave., Chicago, Ill.
Tenney Engineering Inc., 26 Avenue B, Newark, N. J.
Thermo Instruments Co., 1066 El Camino Real, Belmont, Calif.

CONTROLS—Liquid Level

Airlectron, Inc., P. O. Box 151, Caldwell, N. J.
Aquatrol, Inc., 330 Milwaukee Ave., Chicago, Ill.
Associated Valve & Engineering Co., 1150 W. Marquette Rd., Chicago 21, Ill.

Controls

Austin Co., Special Devices Div., 19 Rector St., New York 6, N. Y.
Automatic Temperature Control Co., Inc., 5206 Pulaski Ave., Philadelphia 44, Pa.
Bailey Meter Co., 1044 Ivanhoe Rd., Cleveland 10, Ohio
Colloid Equipment Co., Inc., 48 Church St., New York, N. Y.
Conoflow Corp., 2100 Arch St., Philadelphia 3, Pa.
Coral Designs Div., Henry G. Dietz Co., 12–16 Astoria Blvd., Long Island City 2, N. Y.
Cutler-Hammer, Inc., 412 No. 12th St., Milwaukee 1, Wis.
Eclipse Fuel Engineering Co., 705 S. Main St., Rockford, Ill.
Engineering Laboratories, Inc., 620 E. Fourth St., Tulsa 3, Okla.
Fielden Instrument Corp., 2920 N. 4th St., Philadelphia 33, Pa.
Fischer & Porter Co., 50 County Line Rd., Hatboro, Pa.
Foxboro Co., 86 Neponset Ave., Foxboro, Mass.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
General Control Company, 1200 Soldiers Field Rd., Boston 34, Mass.
General Controls Co., Glendale 1, Calif.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
Industrial Controls, Inc., 525 N. Noble St., Chicago 22, Ill.
Infilco, Inc., P. O. Box 5033, Tucson, Ariz.
Johnson Corp., 809 Wood St., Three Rivers, Mich.
Johnson & Jennings Co., 808 Addison Rd., Cleveland, Ohio
Keckley Co., O. C., 400 Madison St., Chicago 6, Ill.
Kieley & Mueller, Inc., North Bergen, N. J.
Klipfel Mfg. Co., Weller & Zimmerman Aves., Hamilton, Ohio
Lumenite Electronic Co., 407 S. Dearborn St., Chicago 5, Ill.
McAlear Mfg. Co., 1933 S. Western Ave., Chicago, Ill.
Mercoid Corp., 4201 Belmont Ave., Chicago 41, Ill.
Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne & Roberts Aves., Philadelphia 44, Pa. ADV. PG. 88.
Phoenix Precision Instrument Co., 3803 N. 5th St., Philadelphia, Pa.
Photobell Company, 116 Nassau St., New York 7, N. Y.
Powers Regulator Co., 2736 Greenview Ave., Chicago, Ill.
Precision Scientific Co., 3737 Cortland Ave., Chicago, Ill.
Radioactive Products, Inc., 3201 E. Woodbridge St., Detroit 7, Mich.
Swartwout Co., 18457 Euclid Ave., Cleveland, Ohio
Tagliabue Instruments Div. of Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.
Taylor Instrument Co., 95 Ames St., Rochester, N. Y.
Thermo Instruments Co., 1066 El Camino Real, Belmont, Calif.
Westinghouse Electric Corp. P. O. Box 868, Pittsburgh 30, Pa.

CONTROLS—Motor

Allen-Bradley Co., 136 W. Greenfield Ave., Milwaukee, Wis.
Allis Chalmers Mfg. Co., 864 S. 70th St., Milwaukee 1, Wis.
Arrow-Hart & Hegeman Electric Co., 103 Hawthorne St., Hartford, Conn.
Cutler-Hammer, Inc., 412 N. 12th St., Milwaukee 1, Wis.
Ward Leonard Electric Co., 31 South St., Mt. Vernon, N. Y.

CONTROLS—Photographic Exposure

Abrams Instrument Corp., 600–620 E. Schiawassee St., Lansing, Mich.
Austin Co., Special Devices Div., 19 Rector St., New York 6, N. Y.
Automatic Temperature Control Co., Inc., 5206 Pulaski Ave., Philadelphia 44, Pa.
Baldwin Instrument Co., Ltd., Brooklands Works, Dartford, Kent
Berkeley Scientific Co., 6th & Nevin Ave., Richmond, Calif.
Carnine & Bitter, 2332 Ontario Rd. NW, Washington 9, D. C.
Coral Designs Div., Henry G. Dietz Co., 12–16 Astoria Blvd., Long Island City 2, N. Y.
Cramer Co., Inc., R. W., Box 13, Centerbrook, Conn.
Custom Craft Mfg. Co., 256 E. 98th St., Brooklyn, N. Y.
Phoenix Precision Instrument Co., 3803 N. 5th St., Philadelphia, Pa.
Photobell Company, 116 Nassau St., New York 7, N. Y.
Photovolt Corp., 95 Madison Ave., New York 16, N. Y. ADV. PG. 104.
Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.

CONTROLS—Pressure

American Oxygen Service Corp., 600 Essex St., Harrison, N. J.
Aquatrol, Inc., 330 Milwaukee Ave., Chicago, Ill.
Associated Valve & Engineering Co., 1150 W. Marquette Rd., Chicago 21, Ill.
Austin Co., Special Devices Div., 19 Rector St., New York 6, N. Y.
Automatic Temperature Control Co., Inc., 5206 Pulaski Ave., Philadelphia 44, Pa.
Bailey Meter Co., 1044 Ivanhoe Rd., Cleveland 10, Ohio
Bar-Ray Products, Inc., 209 25th St., Brooklyn, N. Y.
Bowser, Inc., Refrigerator Div., Terryville, Conn.
Buckeye Air Compressor Co., 414 Littell Ave., Dayton, Ohio
Carnine & Bitter, 2332 Ontario Rd. NW, Washington 9, D. C.
Cash Valve Mfg. Corp., A. W., 6666 Wabash Ave., Decatur, Ill.
Conoflow Corp., 2100 Arch St., Philadelphia 3, Pa.
Coral Designs Div., Henry G. Dietz Co., 12–16 Astoria Blvd., Long Island City 2, N. Y.
Cutler-Hammer, Inc., 412 No. 12th St., Milwaukee 1, Wis.
Eclipse Fuel Engineering Co., 705 S. Main St., Rockford, Ill.
Eclipse-Pioneer Div,. Bendix Aviation Corp., Teterboro, N. J.
Fischer & Porter Co., 50 County Line Rd., Hatboro, Pa.
Flader, Inc., Fredric, North Tonawanda, N. Y.
Foxboro Co., 86 Neponset Ave., Foxboro, Mass.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Gas & Oil Industry Laboratories, Inc., 2 Paine Ave., Irvington 11, N. J.
General Controls Co., Glendale 1, Calif.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
Hanna Engineering Co., Chicago, Ill.
Hannifin Corporation, 1194 S. Kilbourn Ave., Chicago 24, Ill.
Industrial Controls, Inc., 525 N. Noble St., Chicago 22, Ill.
Industrial Electronics, Inc., 8060 Wheeler St., Detroit 10, Mich.
Keckley Co., O. C., 400 Madison St., Chicago 6, Ill.
Kieley & Mueller, Inc., North Bergen, N. J.

Controls

Klipfel Mfg. Co., Weller & Zimmerman Aves., Hamilton, Ohio
Leahy Mfg. Co., East 8th & Alameda, Los Angeles 21, Calif.
McAlear Mfg. Co., 1933 S. Western Ave., Chicago, Ill.
M. C. Mfg. Co., Lake Orion, Mich.
Mercoid Corp., 4201 Belmont Ave., Chicago 41, Ill.
Minneapolis-Honeywell Regulator Co., 2753 Fourth Ave., S., Minneapolis, Minn.
Nageldinger & Son, John, 409 E. 91st St., New York, N. Y.
Numatics, McLeod Ave., Milford, Mich.
Powers Regulator Co., 2736 Greenview Ave., Chicago, Ill.
Reynolds Gas Regulator Co., Anderson, Ind.
Robert's Brass Mfg. Co., 5435 W. Fort St., Detroit 9, Mich.
Ross Operating Valve Co., Detroit, Mich.
Swartwout Co., 18457 Euclid Ave., Cleveland, Ohio
Tagliabue Instruments Div. of Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.
Taylor Instrument Co., 95 Ames St., Rochester, N. Y.
Trans-Sonics, Inc., Bedford Airport, Bedford, Mass.
Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa.

CONTROLS—Remote

Aeronautical Research Labs., General Mills, Inc., 2010 E. Hennepin Ave., Minneapolis 13, Minn. ADV. PG. 99.
Servomechanisms, Inc., 142 Mineola Blvd., Mineola, N. Y. ADV. PG. 80.

CONTROLS—Servo

Aeronautical Research Labs., General Mills, Inc., 2010 E. Hennepin Ave., Minneapolis 13, Minn. ADV. PG. 99.
Airlectron, Inc., P. O. Box 151, Caldwell, N. J.
American Electric Motors, Inc., 4811–13 Telegraph Rd., Los Angeles, Calif.
American Electroneering Co., 2112 S. LaBrea Ave., Los Angeles, Calif.
Arlington Electric Products, Inc., 500 W. 52nd St., New York, N. Y.
Arma Corp., 254 36th St., Brooklyn 32, N. Y.
Austin Co., Special Devices Div., 19 Rector St., New York 5, N. Y.
Automatic Temperature Control Co., Inc., 5206 Pulaski Ave., Philadelphia 44, Pa.
Berkshire Laboratories, P. O. Box 70, Concord, Mass.
Carnine & Bitter, 2332 Ontario Rd. NW, Washington 9, D. C.
Eclipse-Pioneer Div. of Bendix Aviation Corp., Teterboro, N. J.
Electronic Associates, Inc., Long Branch, N. J.
Flader, Inc., Fredric, North Tonawanda, N. Y.
Gaveco Labs., Inc., 2 East End Ave., New York 21, N. Y.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne & Roberts Aves., Philadelphia 44, Pa. ADV. PG. 88.
Servomechanisms, Inc., 142 Mineola Blvd., Mineola, N. Y. ADV. PG. 80.
Servo-Tek Products Co., 4 Godwin Ave., Paterson 1, N. J.
Standard Electronics Research Corp., 2 East End Ave., New York 21, N. Y.
Taylor Instrument Co., 95 Ames St., Rochester, N. Y.
Teletronics Laboratory, Inc., 352 Maple Ave., Westbury, N. Y.

CONTROLS—Specific Gravity

Austin Co., Special Devices Div., 19 Rector St., New York 6, N. Y.

Controls

Automatic Temperature Control Co., Inc., 5206 Pulaski Ave., Philadelphia 44, Pa.
Engineering Laboratories, Inc., 620 E. Fourth St., Tulsa 3, Okla.
Fischer & Porter Co., 50 County Line Rd., Hatboro, Pa.
Foxboro Co., 86 Neponset Ave., Foxboro, Mass.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Leeds & Northrup Co., 4970 Stenton Ave., Philadelphia 44, Pa.
Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne & Roberts Aves., Philadelphia 44, Pa. ADV. PG. 88.
Taylor Instrument Co., 95 Ames St., Rochester, N. Y.
Thermo Instruments Co., 1066 El Camino Real, Belmont, Calif.

CONTROLS—Temperature

American Electroneering Co., 2112 S. LaBrea Ave., Los Angeles, Calif.
Austin Co., Special Devices Div., 19 Rector St., New York 6, N. Y.
Bailey Meter Co., 1044 Ivanhoe Rd., Cleveland 10, Ohio
Bar-Ray Products, Inc., 209 25th St., Brooklyn, N. Y.
Belke Mfg. Co., 947 N. Cicero Ave., Chicago 51, Ill.
Bowser, Inc., Refrigeration Div., Terryville, Conn.
Carnine & Bitter, 2332 Ontario Rd., NW, Washington 9, D. C.
Colloid Equipment Co., Inc., 48 Church St., New York, N. Y.
Cutler-Hammer, Inc., 412 N. 12th St., Milwaukee 1, Wis.
Edison Inc., Thomas A., Instrument Div., West Orange, N. J.
Eclipse Fuel Engineering Co., 705 S. Main St., Rockford, Ill.
Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.
Fischer & Porter Co., 50 County Line Rd., Hatboro, Pa.
Foxboro Co., 86 Neponset Ave., Foxboro, Mass.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
General Controls Co., Glendale 1, Calif.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
Gordon Co., Claud S., 3000 S. Wallace St., Chicago 16, Ill.
Illinois Testing Labs., Inc., 420 N. LaSalle St., Chicago 10, Ill.
Industrial Controls, Inc., 525 N. Noble St., Chicago 22, Ill.
Keckley Co., O. C., 400 Madison St., Chicago 6, Ill.
Klipfel Mfg. Co., Weller & Zimmerman Aves., Hamilton, Ohio
Leahy Mfg. Co., East 8th & Alameda, Los Angeles 21, Calif.
Leeds & Northrup Co., 4970 Stenton Ave., Philadelphia 44, Pa.
McAlear Mfg. Co., 1933 S. Western Ave., Chicago, Ill.
Macdonald & Co., Inc., W. S., 33 University Rd., Cambridge 38, Mass.
Mercoid Corp., 4201 Belmont Ave., Chicago 41, Ill.
Meters, Inc., 915 Westfield Blvd., Indianapolis 20, Ind.
Minneapolis-Honeywell Regulator Co., 2753 Fourth Ave., S., Minneapolis, Minn.
Mullard Overseas Ltd., Century House, Shaftesbury Ave., London, W. C. 2.
Photobell Company, 116 Nassau St., New York 7, N. Y.
Powers Regulator Co., 2736 Greenview Ave., Chicago, Ill.
Precision Scientific Co., 3737 Cortland Ave., Chicago, Ill.
Process & Instruments, 60 Greenpoint Ave., Brooklyn 22, N. Y.

Controls

Pyrometer Instrument Co., Inc., Bergenfield, N. J.
Spencer-Kennedy Labs, Inc., 186 Massachusetts Ave., Cambridge 39, Mass. ADV. PG. 92.
Standard Electronics Research Corp., 2 East End Ave., New York 21, N. Y.
Swartwout Co., 18457 Euclid Ave., Cleveland, Ohio
Tagliabue Instruments Div. of Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.
Taylor Instrument Co., 95 Ames St., Rochester, N. Y.
Tenney Engineering, Inc., 26 Avenue B, Newark 5, N. J.
Thermo Electric Mfg. Co., 480 W. Locust St., Dubuque, Ia.
Thwing-Albert Instrument Co., 5351 Pulaski Ave., Philadelphia 44, Pa.
Trans-Sonics, Inc., Bedford Airport, Bedford, Mass.
Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.
Wheelco Instrument Co., 847 W. Harrison St., Chicago 7, Ill.

CONTROLS—Timing

Abrams Instrument Corp., 600–620 E. Schiawassee St., Lansing, Mich.
Airlectron, Inc., P. O. Box 151, Caldwell, N. J.
American Chronoscope Corp., 316 W. First St., Mt. Vernon, N. Y.
Associated Valve & Engineering Co., 1150 W. Marquette Rd., Chicago 21, Ill.
Austin Co., Special Devices Div., 19 Rector St., New York 6, N. Y.
Atomic Instrument Co., 84 Massachusetts Ave., Cambridge 39, Mass. ADV. PG. 101.
Automatic Temperature Control Co., Inc., 5206 Pulaski Ave., Philadelphia 44, Pa.
Belke Mfg. Co., 947 N. Cicero Ave., Chicago 51, Ill.
Berkeley Scientific Co., 6th & Nevin Ave., Richmond, Calif.
Berkshire Laboratories, P. O. Box 70, Concord, Mass.
Carnine & Bitter, 2332 Ontario Rd. NW, Washington 9, D. C.
Colloid Equipment Co., Inc., 48 Church St., New York, N. Y.
Coral Designs Div., Henry G. Dietz Co., 12–16 Astoria Blvd., Long Island City 2, N. Y.
Cramer Co., Inc., R. W., Box 13, Centerbrook, Conn.
Custom Craft Mfg. Co., 256 E. 98th St., Brooklyn, N. Y.
Cutler-Hammer, Inc., 412 No. 12th St., Milwaukee 1, Wis.
Cyclotron Specialties Co., Moraga 8, Calif.
Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.
Edison, Inc., Thomas A., Instrument Div., West Orange, N. J.
Elm Laboratories, 18 South Broadway, Dobbs Ferry, N. Y.
Gale Dorothea Mechanisms, 37–61 85th St., Jackson Heights, L. I., N. Y.
General Control Company, 1200 Soldiers Field Rd., Boston 34, Mass.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
Gorrell & Gorrell, Haworth, N. J.
Industrial Controls, Inc., 525 N. Noble St., Chicago 22, Ill.
Industrial Science Associates, 542 Fifth Ave., New York 19, N. Y.
Leland Instruments Ltd., 22–23 Millbank, London, S. W. 1
Lumenite Electronic Co., 407 S. Dearborn St., Chicago 5, Ill.
Mallory & Co., Inc., P. R., 3029 E. Washington St., Indianapolis 6, Ind.
Mullard Overseas Ltd., Century House, Shaftesbury Ave., London, W. C. 2.

Controls

Paragon Electric Company, Two Rivers, Wisconsin.
Photobell Company, 116 Nassau St., New York 7, N. Y.
Potter Instrument Co., 115 Cutter Mill Rd., Great Neck, N. Y.
Special Instruments Laboratory, Inc., 1003 Highland Ave., Knoxville, Tenn. ADV. PG. 91.
Tagliabue Instruments Div. of Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.
Taylor Instrument Co., 95 Ames St., Rochester, N. Y.
Tech Laboratories, Inc., Bergen & Edsall Blvds., Palisades Park, N. J.
Teletronics Laboratory, Inc., 352 Maple Ave., Westbury, N. Y.
Tracerlab, Inc., 130 High St., Boston 10, Mass. ADV. PG. 74, 75.
Ward Leonard Electric Co., 31 South St., Mt. Vernon, N. Y.
Wayne-Kerr Laboratories, Ltd., New Malden, Surrey, England
Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa.
Wilson & Co., G. C., 2 N. Passaic Ave., Chatham, N. J.
Zenith Electric Co., 152 W. Walton St., Chicago 10, Ill.

CONTROLS—Vacuum

Aquatrol, Inc., 330 Milwaukee Ave., Chicago, Ill.
Associated Valve & Engineering Co., 1150 W. Marquette Rd., Chicago 21, Ill.
Austin Co., Special Devices Div., 19 Rector St., New York 6, N. Y.
Automatic Temperature Control Co., Inc., 5206 Pulaski Ave., Philadelphia 44, Pa.
Bowser, Inc., Refrigeration Div., Terryville, Conn.
Carnine & Bitter, 2332 Ontario Rd. NW, Washington 9, D. C.
Conaflow Corp., 2100 Arch St., Philadelphia 3, Pa.
Coral Designs Div., Henry G. Dietz Co., 12–16 Astoria Blvd., Long Island City 2, N. Y.
Cutler-Hammer, Inc., 412 N. 12th St., Milwaukee 1, Wis.
Distillation Products Industries, Div. of Eastman-Kodak Co., 755 Ridge Rd. W., Rochester 3, N. Y.
Foxboro Co., 86 Neponset Ave., Foxboro, Mass.
Fulton Sylphon Div., Robertshaw-Fulton Controls Co., Knoxville 4, Tenn.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
Hastings Instrument Co., Box 1275, Hampton, Va.
Industrial Controls, Inc., 525 N. Noble St., Chicago 22, Ill.
Kieley & Mueller, Inc., North Bergen, N. J.
Kinney Mfg. Co., 3614 Washington St., Boston, Mass.
Mercoid Corp., 4201 Belmont Ave., Chicago 41, Ill.
Minneapolis-Honeywell Regulator Co., 2753 Fourth Ave. S., Minneapolis, Minn.
National Research Corp., 70 Memorial Drive, Cambridge 42, Mass.
Powers Regulator Co., 2736 Greenview Ave., Chicago, Ill.
Precision Scientific Co., 3737 Cortland Ave., Chicago, Ill.
Reynolds Gas Regulator Co., Anderson, Ind.
Scientific Glass Apparatus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.
Tagliabue Instruments Div. of Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.
Taylor Instrument Co., 95 Ames St., Rochester, N. Y.
Tenney Engineering, Inc., 26 Avenue B, Newark 5, N. J.
Vacuum Electronic Engineering Co., 756 Third Ave., Brooklyn 32, N. Y.

Counters

CONTROLS—Ventilating Control System

Bowser, Inc., Refrigeration Div., Terryville, Conn.
Conoflow Corp., 2100 Arch St., Philadelphia 3, Pa.
Coral Designs Div., Henry G. Dietz Co., 12–16 Astoria Blvd., Long Island City 2, N. Y.
Cutler-Hammer, Inc., 412 N. 12th St., Milwaukee 1, Wis.
Foxboro Co., 86 Neponset Ave., Foxboro, Mass.
Houston Blow Pipe & Sheet Metal Works, P. O. Box 1692, Houston 1, Texas
Mercoid Corp., 4201 Belmont Ave., Chicago 41, Ill.
Minneapolis-Honeywell Regulator Co., 2753 Fourth Ave. S., Minneapolis, Minn.
Powers Regulator Co., 2736 Greenview Ave., Chicago, Ill.
Process & Instruments, 60 Greenpoint Ave., Brooklyn 22, N. Y.
Rotron Mfg. Co., Inc., 7 Schoonmaker Lane, Woodstock, N. Y.
Taylor Instrument Co., 95 Ames St., Rochester, N. Y.

COSMIC RAY BALLOONS

Aeronautical Research Labs, General Mills, Inc., 2010 E. Hennepin Ave., Minneapolis 13, Minn. ADV. PG. 99.

COUNTERS—Crystal Conduction

Standard Electronics Research Corp., 2 East End Ave., New York 21, N. Y.

COUNTERS—Flow

Abrams Instrument Corp., 600–620 E. Schiawassee St., Lansing, Mich.
Austin Co., Special Devices Div., 19 Rector St., New York 6, N. Y.
Bailey Meter Co., 1044 Ivanhoe Rd., Cleveland 10, Ohio
Carnine & Bitter, 2332 Ontario Rd. NW, Washington 9, D. C.
Industrial Controls, Inc., 525 N. Noble St., Chicago 22, Ill.
Kieley & Mueller, Inc., North Bergen, N. J.
Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne & Roberts Aves., Philadelphia 44, Pa. ADV. PG. 88.
Nuclear Instrument & Chemical Corp., 223 W. Erie St., Chicago 10, Ill. ADV. PG. Back Cover.
Nuclear Measurements Corp., 3339 Central Ave., Indianapolis, Ind. ADV. PG. 96, 97.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102
Research Equipment & Service, 6054 Woodlawn Ave., Chicago 37, Ill.
Wood Counter Laboratory, N., 5646 Harper Ave., Chicago 37, Ill. ADV. PG. 104.

COUNTERS—Proportional

Anton Electronic Labs., Inc., 1226–38 Flushing Ave., Brooklyn 6, N. Y. ADV. PG. 89.
Atomic Instrument Co., 84 Massachusetts Ave., Cambridge 39, Mass. ADV. PG. 101.
Austin Co., Special Devices Div., 19 Rector St., New York 6, N. Y.
Baldwin Instrument Co., Ltd., Brooklands Works, Dartford, Kent
Carnine & Bitter, 2332 Ontario Rd. NW, Washington 9, D. C.
Chatham Electronics Corp., 475 Washington St., Newark 2, N. J.
Electronic Products Co., 111 E. 3rd St., Mt. Vernon, N. Y.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.

Counters

General Electric Co., Electronics Dept., Electronics Park, Syracuse, N. Y. ADV. PGS. 65 to 72.
Industrial Controls, Inc., 525 N. Noble St., Chicago 22, Ill.
Kisley & Mauller, Inc., North Bergen, N. J.
Minnesota Electronics Corp., 97 E. Fifth St., St. Paul 1, Minn.
Nuclear Development Laboratory, P. O. Box 7034, Kansas City, Mo.
Nuclear Instrument & Chemical Corp., 223 W. Erie St., Chicago 10, Ill. ADV. PG. Back Cover.
Nuclear Measurements Corp., 3339 Central Ave., Indianapolis, Ind. ADV. PG. 96, 97.
Nuclear Research Corp., 112 S. 16th St., Philadelphia 2, Pa. ADV. PG. 109.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Servo-Tek Products Co., 4 Godwin Ave., Paterson 1, N. J.
Standard Electronics Research Corp., 2 East End Ave., New York 21, N. Y.
Technical Associates, Inc., 3730 San Fernando Rd., Glendale 4, Calif. ADV. PG. 94.
Tracerlab, Inc., 130 High St., Boston 10, Mass. ADV. PG. 74, 75.
Victoreen Instrument Co., 3800 Perkins Ave., Cleveland, Ohio. ADV. PG. Inside Front Cover.
Wood Counter Laboratory, N., 5646 Harper Ave., Chicago 37, Ill. ADV. PG. 104.

COUNTERS—Radiation

Able Scientific Glass Apparatus Co., 6859 South Anthony Ave., Chicago 37, Ill. ADV. PG. 106.
Abrams Instrument Corp., 600–620 E. Schiawassee St., Lansing, Mich.
Amperex Electronic Corp., 25 Washington St., Brooklyn 1, N. Y.
Anton Electronic Labs., Inc., 1226–38 Flushing Ave., Brooklyn 6, N. Y. ADV. PG. 89.
Atomic Instrument Co., 84 Massachusetts Ave., Cambridge 39, Mass. ADV. PG. 101.
Austin Co., Special Devices Div., 19 Rector St., New York 6, N. Y.
Baldwin Instrument Co., Ltd., Brooklands Works, Dartford, Kent
Berkeley Scientific Co., 6th & Nevin Ave., Richmond, Calif.
Chatham Electronics Corp., 475 Washington St., Newark 2, N. J.
Cinema-Television Ltd., Worsley Bridge Rd., London, S. E. 26
Clarkstan Corp., 11921 SW Pico Blvd., Los Angeles 64, Calif.
Cossor (Candada) Ltd., 301 Windsor St., Halifax, N. S., Canada
Cyclotron Specialties Co., Moraga 8, Calif.
Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.
Electronic Products Co., 111 E. 3rd St., Mt. Vernon, N. Y.
El-Tronics, Inc., 2649 N. Howard St., Philadelphia 33, Pa. ADV. PG. 76, 77.
Flader, Inc., Fredric, North Tonawanda, N. Y.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
General Electric Co., Electronics Dept., Electronics Park, Syracuse, N. Y. ADV. PGS. 65 to 72.
General Electric X-Ray Corp., 4855 Electric Ave., Milwaukee, Wis. ADV. PG. 73.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Interelectronics Corp., 2432 Grand Concourse, New York 57, N. Y.
Kelley-Koett Instrument Co., 936 York St., Cincinnati 14, Ohio. ADV. PG. Inside Back Cover.
Marconi Instruments, Ltd., 23–25 Beaver St., New York 4, N. Y.
Menlo Research Laboratory, Menlo Park, Calif.

Counters

Mullard Overseas Ltd., Century House, Shaftesbury Ave., London, W. C. 2.
National Radiac, Inc., 475 Washington St., Newark 2, N. J.
Nuclear Development Laboratory, P. O. Box 7034, Kansas City, Mo.
Nuclear Instrument & Chemical Corp., 223 W. Erie St., Chicago 10, Ill. ADV. PG. Back Cover.
Nuclear Measurements Corp., 3339 Central Ave., Indianapolis, Ind. ADV. PG. 96, 97.
Nuclear Research Corp., 112 S. 16th St., Philadelphia 2, Pa. ADV. PG. 109.
Nucleonic Corp. of America, 497 Union St., Brooklyn 31, N. Y.
Potter Instrument Co., 115 Cutter Mill Rd., Great Neck, N. Y.
Production Instrument Co., 710 W. Jackson Blvd., Chicago 6, Ill.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Radioactive Products, Inc., 3201 E. Woodbridge St., Detroit 7, Mich.
Radio Corp. of America, RCA Victor Div., Engineering Products Dept., Front & Cooper Sts., Camden, N. J. ADV. PG. 95.
Special Instruments Laboratory, Inc., 1003 Highland Ave., Knoxville, Tenn. ADV. PG. 91.
Standard Electronics Research Corp., 2 East End Ave., New York 21, N. Y.
Streeter-Amet Corp., 4101 Ravenswood Ave., Chicago 13, Ill. ADV. PG. 110.
Technical Associates, 3730 San Fernando Rd., Glendale 4, Calif. ADV. PG. 94.
Technitrol Engineering Corp., 3211 Woodland Ave., Philadelphia 4, Pa.
Tracerlab, Inc., 130 High St., Boston 10, Mass. ADV. PG. 74, 75.
Well Surveys, Inc., 624 E. 4th St., Tulsa 3, Okla.
Western Radiation Labs., 1107 W. 24th St., Los Angeles 27, Calif.
Wood Counter Laboratory, N., 5646 Harper Ave., Chicago 37, Ill. ADV. PG. 104.

COUNTERS—Scintillation

Atomic Instrument Co., 84 Massachusetts Ave., Cambridge 39, Mass. ADV. PG. 101.
Baldwin Instrument Co., Ltd., Brooklands Works, Dartford, Kent
Clarkstan Corp., 11921 SW Pico Blvd., Los Angeles 64, Calif.
Electronic Products Co., 111 E. 3rd St., Mt. Vernon, N. Y.
Flader, Inc., Fredric, North Tonawanda, N. Y.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
Heintz & Kaufman Div. of The Robert Dollar Co., 947 Broadway, Redwood City, Calif.
Interelectronics Corp., 2432 Grand Concourse, New York 57, N. Y.
Macdonald Co., Inc., W. S., 33 University Rd., Cambridge 38, Mass.
National Radiac, Inc., 475 Washington St., Newark 2, N. J.
Nuclear Instrument & Chemical Corp., 223 W. Erie St., Chicago 10, Ill. ADV. PG. Back Cover.
Nuclear Measurements Corp., 3339 Central Ave., Indianapolis, Ind. ADV. PG. 96, 97.
Nuclear Research Corp., 112 S. 16th St., Philadelphia 2, Pa. ADV. PG. 109.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Radioactive Products, Inc., 3201 E. Woodbridge St., Detroit 7, Mich.
Radio Corp. of America, RCA Victor Div., Engineering Products Dept., Front & Cooper Sts., Camden, N. J. ADV. PG. 95.
Standard Electronics Research Corp., 2 East End Ave., New York 21, N. Y.

Crystals

Technical Associates, Inc., 3730 San Fernando Rd., Glendale 4, Calif. ADV. PG. 94.
Technitrol Engineering Corp., 3211 Woodland Ave., Philadelphia 4, Pa.
Tracerlab, Inc., 130 High St., Boston 10, Mass. ADV. PG. 74, 75.

CRYSTALS—Scintillation

Jasonals Chemical Corp., 1085 Myrtle Ave., Brooklyn 6, N. Y.
Nuclear Research Corp., 112 S. 16th St., Philadelphia 2, Pa. ADV. PG. 109.
Organic Specialties, Inc., 109 Fifth Ave., Paterson, N. J.
Reilly Tar & Chemical Corp., 1615 Merchants Bank Bldg., 11 S. Meridan St., Indianapolis, Ind.
Technical Associates, Inc., 3730 San Fernando Rd., Glendale 4, Calif. ADV. PG. 94.

CRYSTALS—Synthetic

Bell Telephone Laboratories, Inc., 463 West St., New York 14, N. Y.
Brush Development Co., 3405 Perkins Ave., Cleveland 14, Ohio
Linde Air Products Co., Unit of Union Carbide & Carbon Corp., 30 E. 42nd St., New York 17, N. Y.

DECADE BOXES—Resistance

Berkshire Laboratories, P. O. Box 70, Concord, Mass.
Brown Electro-Measurement Corp., 4637 S. E. Hawthorne Blvd., Portland 15, Oregon.
Cinema Engineering Co., 1510 W. Verdugo Ave., Burbank, Calif.
Daven Co., 191 Central Ave., Newark 4, N. J.
El-Tronics, Inc., 2649 N. Howard St., Philadelphia 33, Pa. ADV. PG. 76, 77.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Leeds & Northrup Co., 4970 Stenton Ave., Philadelphia 44, Pa.
Shallcross Mfg. Co., 10 Jackson Ave., Collingdale, Pa.
Sticht Co., Inc., Herman H., 27 Park Place, New York 7, N. Y.
Tech Laboratories, Inc., Bergen & Edsall Blvds., Palisades Park, N. J.

DECONTAMINANTS

Allied Chemical & Dye Corp., 40 Rector St., New York 6, N. Y.
Atomlab, 489 Fifth Avenue, New York, N. Y.
Carbide & Carbon Chemicals Corp., 30 East 42nd St., New York 17, N. Y.
du Pont de Nemours & Co., Inc., E. I., Wilmington 98, Del.
Rohm & Haas Co., Washington Square, Philadelphia 5, Pa.
Wolfe & Co., Jacques, P. O. Box 839, Passaic, N. J.

DEHUMIDIFIERS

American Thermal Industries, Inc., 440 Illinois St., Detroit, Mich.
Buffalo Forge Co., 473 Broadway, Buffalo, N. Y.
Carbide & Carbon Chemicals Div., Union Carbide & Carbon Corp., 30 E. 42nd St., New York 17, N. Y.
Clarage Fan Co., 719 Porter St., Kalamazoo, Mich.
Emerson-Sack-Warner Corp., 92 Beverly, Boston, Mass.
Metrex Valve Co., Hirschberg Blvd. & Franklin Ave., Franklin Park, Ill.
Pittsburgh Lectrodryer Corp., P. O. Box 1766, Pittsburgh, Pa.
United States Air Conditioning Corp., Como Ave. SE at 33rd, Minneapolis 14, Minn.
Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa.
York Corp., York, Pa.

Detectors

DENSITOMETERS

American Scientific Co., P. O. Box 1, Highbridge Station, New York 52, N. Y.
Baldwin Instrument Co., Ltd., Brooklands Works, Dartford, Kent
Bausch & Lomb Optical Co., 635 St. Paul St., Rochester 2, N. Y.
Davies Laboratories, Inc., 4705 Queensbury Rd., Riverdale, Md.
Eastman Kodak Co., Rochester 4, N. Y.
Ess Instrument Co., 98 S. Washington St., Bergenfield, N. J.
Fischer & Porter Co., 50 County Line Rd., Hatboro, Pa.
Heincke Instrument Corp., 315 Alexander St., Rochester 4, N. Y.
Jarrell-Ash Co., 165 Newberry St., Boston 16, Mass.
Photobell Company, 116 Nassau St., New York 7, N. Y.
Photovolt Corp., 95 Madison Ave., New York 16, N. Y. ADV. PG. 104.
Standard Electronics Research Corp., 2 East End Ave., New York 21, N. Y.
Welch Scientific Co., W. M., 1515 Sedgwick St., Chicago 10, Ill.
Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.

DESKS—Laboratory

Blickman, Inc., S., 7900 Gregory Ave., Weehawken, N. J. ADV. PG. 2.
Brooklyn Hospital Equipment Co., Inc., 196 Lexington Ave., New York, N. Y.
Eimer & Amend, 635 Greenwich St., New York, N. Y.
Emerson-Sack-Warner Corp., 92 Beverly, Boston, Mass.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Houston Blow Pipe & Sheet Metal Works, P. O. Box 1692, Houston 1, Texas
Kewanee Mfg. Co., 5083 S. Center St., Adrian, Mich.

DETECTORS—Alpha

Able Scientific Glass Apparatus Co., 6859 South Anthony Ave., Chicago 37, Ill. ADV. PG. 106.
Anton Electronic Labs., Inc., 1226–38 Flushing Ave., Brooklyn 6, N. Y. ADV. PG. 89.
Atomic Instrument Co., 84 Massachusetts Ave., Cambridge 39, Mass. ADV. PG. 101.
Baldwin Instrument Co., Ltd., Brooklands Works, Dartford, Kent.
Beckman Instruments, Inc., 820 Mission St., South Pasadena, Calif. ADV. PG. 85.
Clarkstan Corp., 11921 SW Pico Blvd., Los Angeles 64, Calif.
Cyclotron Specialties Co., Moraga 8, Calif.
Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.
Electronic Products Co., 111 E. 3rd St., Mt. Vernon, N. Y.
El-Tronics, Inc., 2649 N. Howard St., Philadelphia 33, Pa. ADV. PG. 76, 77.
Fisher Research Lab., Inc., 1961 University Ave., Palo Alto, Calif.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
General Electric Co., Electronics Dept., Electronics Park, Syracuse, N. Y. ADV. PGS. 65 to 72.
Interelectronics Corp., 2432 Grand Concourse, New York 57, N. Y.
Kelley-Koett Instrument Co., 936 York St., Cincinnati 14, Ohio. ADV. PG. Inside Back Cover.
Macdonald Co., Inc., W. S., 33 University Rd., Cambridge 38, Mass.

Detectors

Mullard Overseas Ltd., Century House, Shaftesbury Ave., London, W. C. 2.
Nuclear Development Laboratory, P. O. Box 7034, Kansas City, Mo.
Nuclear Instrument & Chemical Corp., 223 W. Erie St., Chicago 10, Ill. ADV. PG. Back Cover.
Nuclear Measurements Corp., 3339 Central Ave., Indianapolis, Ind. ADV. PG. 96, 97.
Nuclear Research Corp., 112 S. 16th St., Philadelphia 2, Pa. ADV. PG. 109.
Nucleonic Corp. of America, 497 Union St., Brooklyn 31, N. Y.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Radioactive Products, Inc., 3201 E. Woodbridge St., Detroit 7, Mich.
Special Instruments Laboratory, Inc., 1003 Highland Ave., Knoxville, Tenn. ADV. PG. 91.
Technical Associates, Inc., 3730 San Fernado Rd., Glendale 4, Calif. ADV. PG. 94.
Tracerlab, Inc., 130 High St., Boston 10, Mass. ADV. PG. 74, 75.
Wayne-Kerr Laboratories, Ltd., New Malden, Surrey, England
Western Radiation Labs., 1107 W. 24th St., Los Angeles 27, Calif.
Wood Counter Laboratory, N., 5646 Harper Ave., Chicago 37, Ill. ADV. PG. 104.

DETECTORS—Beta

Able Scientific Glass Apparatus Co., 6859 South Anthony Ave., Chicago 37, Ill. ADV. PG. 106.
Anton Electronic Labs., Inc., 1226–38 Flushing Ave., Brooklyn 6, N. Y. ADV. PG. 89.
Atomic Instrument Co., 84 Massachusetts Ave., Cambridge, Mass. ADV. PG. 101.
Baldwin Instrument Co., Ltd., Brooklands Works, Dartford, Kent
Beckman Instruments, Inc., 820 Mission St., South Pasadena, Calif. ADV. PG. 85.
Berkeley Scientific Co., 6th & Nevin Ave., Richmond, Calif.
Chatham Electronics Corp., 475 Washington St., Newark 2, N. J.
Cyclotron Specialties Co., Moraga 8, Calif.
Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.
Electronic Products Co., 111 E. 3rd St., Mt. Vernon, N. Y.
El-Tronics, Inc., 2649 N. Howard St., Philadelphia 33, Pa. ADV. PG. 76, 77.
Fisher Research Lab., Inc., 1961 University Ave., Palo Alto, Calif.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
General Electric Co., Electronics Dept., Electronics Park, Syracuse, N. Y. ADV. PGS. 65 to 72.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Interelectronics Corp., 2432 Grand Concourse, New York 57, N. Y.
Kelley-Koett Instrument Co., 936 York St., Cincinnati 14, Ohio. ADV. PG. Inside Back Cover.
Macdonald Co., Inc., W. S., 33 University Rd., Cambridge 38, Mass.
Mullard Overseas Ltd., Century House, Shaftesbury Ave., London, W. C. 2
Nuclear Development Laboratory, P. O. Box 7034, Kansas City, Mo.
Nuclear Instrument & Chemical Corp., 223 W. Erie St., Chicago 10, Ill. ADV. PG. Back Cover.
Nuclear Measurements Corp., 3339 Central Ave., Indianapolis, Ind. ADV. PG. 96, 97.
Nuclear Research Corp., 112 S. 16th St., Philadelphia 2, Pa. ADV. PG. 109.
Nucleonic Corp. of America, 497 Union St., Brooklyn 31, N. Y.

Detectors

Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Radioactive Products, Inc., 3201 E. Woodridge St., Detroit 7, Mich.
Raytheon Mfg. Co., Special Tube Section, 55 Chapel St., Newton 48, Mass. ADV. PG. 112.
Special Instruments Laboratory, Inc., 1003 Highland Ave., Knoxville, Tenn. ADV. PG. 91.
Technical Associates, Inc., 3730 San Fernando Rd., Glendale 4, Calif. ADV. PG. 94.
Tracerlab Inc., 130 High St., Boston 10, Mass. ADV. PG. 74, 75.
Wayne-Kerr Laboratories, Ltd., New Malden, Surrey, England
Well Surveys, Inc., 624 E. 4th St., Tulsa 3, Okla.
Western Radiation Labs., 1107 W. 24th St., Los Angeles 27, Calif.
Wood Counter Laboratory, N., 5646 Harper Ave., Chicago 37, Ill. ADV. PG. 104.

DETECTORS—Gamma

Able Scientific Glass Apparatus Co., 6859 South Anthony Ave., Chicago 37, Ill. ADV. PG. 106.
Anton Electronic Labs., Inc., 1226–38 Flushing Ave., Brooklyn 6, N. Y. ADV. PG. 89.
Atomic Instrument Co., 84 Massachusetts Ave., Cambridge 39, Mass. ADV. PG. 101.
Austin Co., Special Devices Div., 19 Rector St., New York 6, N. Y.
Baldwin Instrument Co., Ltd., Brooklands Works, Dartford, Kent
Beckman, Inc., Arnold O., 1020 Mission St., South Pasadena, Calif.
Beckman Instruments, Inc., 820 Mission St., South Pasadena, Calif. ADV. PG. 85.
Berkeley Scientific Co., 6th & Nevin Ave., Richmond, Calif.
Cambridge Instrument Co., Inc., 3786 Grand Central Terminal, New York 17, N. Y.
Chatham Electronics Corp., 475 Washington St., Newark 2, N. J.
Cinema-Television Ltd., Worsley Bridge Rd., London, S. E. 26
Cyclotron Specialities Co., Moraga 8, Calif.
Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.
Electronic Products Co., 111 E. 3rd St., Mt. Vernon, N. Y.
El-Tronics, Inc., 2649 N. Howard St., Philadelphia 33, Pa. ADV. PG. 76, 77.
Engineering Laboratories, Inc., 620 E. Fourth St., Tulsa 3, Okla.
Fisher Research Lab., Inc., 1961 University Ave., Palo Alto, Calif.
Fleming Radio (Developments) Ltd., 18–20 Laystall St., London, E. C. 1.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
General Electric Co., Electronics Dept., Electronics Park, Syracuse, N. Y. ADV. PGS. 65 to 72.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Interelectronics Corp., 2432 Grand Concourse, New York 57, N. Y.
Kelley-Koett Instrument Co., 936 York St., Cincinnati 14, Ohio. ADV. PG. Inside Back Cover.
Linde Air Products Co., Unit of Union Carbide & Carbon Corp., 30 E. 42nd St., New York 17, N. Y.
Macdonald Co., Inc., W. S., 33 University Rd., Cambridge 38, Mass.
Menlo Research Laboratory, Menlo Park, Calif.
Mullard Overseas Ltd., Century House, Shaftesbury Ave., London, W. C. 2.
National Radiac, Inc., 475 Washington St., Newark 2, N. J.
Nuclear Development Laboratory, P. O. Box 7034, Kansas City, Mo.

Detectors

Nuclear Instrument & Chemical Corp., 223 W. Erie St., Chicago 10, Ill. ADV. PG. Back Cover.
Nuclear Measurements Corp., 3339 Central Ave., Indianapolis, Ind. ADV. PG. 96, 97.
Nuclear Research Corp., 112 S. 16th St., Philadelphia 2, Pa. ADV. PG. 109.
Nucleonic Corp. of America, 497 Union St., Brooklyn 31, N. Y.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Radioactive Products, Inc., 3201 E. Woodbridge St., Detroit 7, Mich.
Raytheon Mfg. Co., Special Tube Section, 55 Chapel St., Newton 58, Mass. ADV. PG. 112.
Special Instruments Laboratory, Inc., 1003 Highland Ave., Knoxville, Tenn. ADV. PG. 91.
Technical Associates, Inc., 3730 San Fernando Rd., Glendale 4, Calif. ADV. PG. 94.
Tracerlab, Inc., 130 High St., Boston 10, Mass. ADV. PG. 74, 75.
Wayne-Kerr Laboratories, Ltd., New Malden, Surrey, England
Well Surveys, Inc., 624 E. 4th St., Tulsa 3, Okla.
Western Radiation Labs., 1107 W. 24th St., Los Angeles 27, Calif.
Wood Counter Laboratory, N., 5646 Harper Ave., Chicago 37, Ill. ADV. PG. 104.

DETECTORS—Hazardous or Poisonous Gas

Cambridge Instrument Co., Inc., 3786 Grand Central Terminal, New York 17, N. Y.
Davis Emergency Equipment Co., Inc., 57 Halleck St., Newark, N. J.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
General Electric Co., Electronics Dept., Electronics Park, Syracuse, N. Y. ADV. PGS. 65 to 72.
Leeds & Northrup Co., 4970 Stenton Ave., Philadelphia 44, Pa.
Mine Safety Appliances Co., Braddock, Thomas & Meade Sts., Pittsburgh 8, Pa.
Nuclear Measurements Corp., 3339 Central Ave., Indianapolis, Ind. ADV. PG. 96, 97.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.

DETECTORS—Leak

Consolidated Engineering Corp., 620 N. Lake Ave., Pasadena 4, Calif. ADV. PG. 82.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
West Coast Electronics Co., 1601 S. Burlington Ave., Los Angeles 6, Calif.

DETECTORS—Neutron

Anton Electronic Labs., Inc., 1226–38 Flushing Ave., Brooklyn 6, N. Y. ADV. PG. 89.
Atomic Instrument Co., 84 Massachusetts Ave., Cambridge 39, Mass. ADV. PG. 101.
Austin Co., Special Devices Div., 19 Rector St., New York 6, N. Y.
Baldwin Instrument Co., Ltd., Brooklands Works, Dartford, Kent
Cambridge Instrument Co., Inc., 3786 Grand Central Terminal, New York 17, N. Y.
Cyclotron Specialities Co., Moraga 8, Calif.
Electronic Products Co., 111 E. 3rd St., Mt. Vernon, N. Y.
Engineering Laboratories, Inc., 620 E. Fourth St., Tulsa 3, Okla.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
Kelley-Koett Instrument Co., 936 York St., Cincinnati 14, Ohio. ADV. PG. Inside Back Cover.
Nuclear Development Laboratory, P.O. Box 7034, Kansas City, Mo.

Dosimeters

Nuclear Instrument & Chemical Corp., 223 W. Erie St., Chicago 10, Ill. ADV. PG. Back Cover.
Nuclear Measurements Corp., 3339 Central Ave., Indianapolis, Ind. ADV. PG. 96, 97.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Technical Associates, Inc., 3730 San Fernando Rd., Glendale 4, Calif. ADV. PG. 94.
Well Surveys, Inc., 624 E. 4th St., Tulsa 3, Okla.
Wood Counter Laboratory, N., 5646 Harper Ave., Chicago 37, Ill. ADV. PG. 104.

DETERGENTS

Alrose Chemical Co., Box 1294, Providence, R. I.
Atlas Powder Co., 904 Market St., Wilmington, Del.
Carbide & Carbon Chemicals Div., Union Carbide & Carbon Corp., 30 E. 42nd St., New York 17, N. Y.
Colloid Equipment Co., Inc., 48 Church St., New York, N. Y.
du Pont de Nemours & Co., Inc., E. I., Wilmington 98, Del.
Hallingshead Corp., R. M., Cocoon Engineering Div., 840 Cooper St., Camden, N. J.
Jasonals Chemical Corp., 1085 Myrtle Ave., Brooklyn 6, N. Y.
Lasting Products Co., 202 S. Franklintown Rd., Baltimore 23, Md.
Linick Chemical Co., 29 E. Madison St., Chicago 2, Ill.
Monsanto Chemical Co., 1700 S. Second St., St. Louis 4, Mo.
Quigley Co., Inc., 527 Fifth Ave., New York, N. Y.
Wolfe & Co., Jacques, P. O. Box 839, Passaic, N. J.

DISTILLATION EQUIPMENT

American Copper & Brass Works, Cincinnati, Ohio
Brighton Copper Works, Inc., 2146 Colerain Ave., Cincinnati, Ohio
Consolidated Siphon Supply Co., 24 Wooster St., New York, N. Y.
Distillation Products Industries, Div. of Eastman-Kodak Co., 755 Ridge Rd. W., Rochester 3, N. Y.
Electric Hotpack Co., Inc., 5035 Cottman Ave., Philadelphia, Pa.
Emerson-Sack-Warner Corp., 92 Beverly, Boston, Mass.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Glass Engineering Laboratories, Belmont, Calif.
Graver Tank & Mfg. Co., Inc., 6300 Todd Ave., East Chicago, Ind.
Houston Blow Pipe & Sheet Metal Works, P. O. Box 1692, Houston 1, Texas
Illinois Water Treatment Co., 858 Cedar St., Rockford, Ill.
Leader Iron Works, Inc., 2110 North Jasper, Decatur, Ill.
Oat & Sons, Inc., Joseph, Broad & Quarry Sts., Philadelphia, Pa.
Pfaudler Co., East Ave. & Clark St., Rochester, N. Y.
Precision Scientific Co., 3737 Cortland Ave., Chicago, Ill.
Scientific Glass Apparatus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.
Struthers-Wells Corp., Warren, Pa.

DOSIMETERS

Ansco Div., General Aniline & Film Corp., Binghamton, N. Y.
Anton Electronic Labs., Inc., 1226–38 Flushing Ave., Brooklyn 6, N. Y. ADV. PG. 89.
Baldwin Instrument Co., Ltd., Brooklands Works, Dartford, Kent
Beckman, Inc., Arnold O., 1020 Mission St., South Pasadena, Calif.
Cambridge Instrument Co., Inc., 3786 Grand Central Terminal, New York 17, N. Y.

Electrical Testing Equipment

Chatham Electronics Corp., 475 Washington St., Newark 2, N. J.
Cinema-Television Ltd., Worsley Bridge Rd., London, S. E. 26
Clarkstan Corp., 11921 SW Pico Blvd., Los Angeles 64, Calif.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
Henson Co., Fred C., 3311 E. Colorado St., Pasadena 8, Calif.
Kelley-Koett Instrument Co., 936 York St., Cincinnati 14, Ohio. ADV. PG. Inside Back Cover.
Landsverk Electrometer Co., Pipping Rd., Cincinnati 31, Ohio.
Marconi Instruments, Ltd., 23–25 Beaver St., New York 4, N. Y.
Photovolt Corp., 95 Madison Ave., New York 16, N. Y. ADV. PG. 104.
Special Instruments Laboratory, Inc., 1003 Highland Ave., Knoxville, Tenn. ADV. PG. 91.
Technical Associates, Inc., 3730 San Fernando Rd., Glendale 4, Calif. ADV. PG. 94.
Tracerlab, Inc., 130 High St., Boston 10, Mass. ADV. PG. 74, 75.

ELECTRICAL TESTING & INDICATING EQUIPMENT

(a) Ammeters
(b) Microammeters
(c) Micro-Microammeters
(d) Milliammeters
(e) Voltmeters
(f) Voltmeters, Electronic

Assembly Products Co., Chagrin Falls 6, Ohio a-b-d-e
Associated Research, 3758 W. Belmont, Chicago 18, Ill. a-b-d-e
Ballantine Laboratories, Inc., Boonton, N. J. f
Beta Electric Corp., 333 E. 103rd St., New York 29, N. Y. b-c-f
Daven Co., 191 Central Ave., Newark 4, N. J. e
DeJur-Amsco Corp., Northern Blvd. at 45th St., Long Island City 1, N. Y. a-b-d-e
Electronic Instrument Co., Inc., 276 Newport St., Brooklyn 12, N. Y. d-e-f
Ferranti Electric Co., 30 Rockefeller Plaza, New York 20, N. Y. a-e
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72. a-b-c-d-e-f
Hewlett-Packard Co., 395 Page Mill Rd., Palo Alto, Calif. d-e-f
Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland, Ohio b-d-e-f
J B T Instruments Inc., 441 Chapel St., New Haven 8, Conn. a-d-e
Krohn-Hite Instrument Co., 580 Massachusetts Ave., Cambridge 39, Mass. f
Marion Electrical Instrument Co., Manchester, N. H. ADV. PG. 98. a-b-d-e
Millivac Instruments, Box 3027, New Haven, Conn. c-f
Radio Corp. of America, RCA Victor Div., Tube Dept., 415 S. Fifth St., Harrison, N. J. ADV. PG. 83, 87. b-e-f
Rawson Electrical Instrument Co., 114 Potter St., Cambridge 42, Mass. a-b-c-d
Sensitive Research Instrument Corp., 9 Elm Ave., Mt. Vernon, N. Y. a-b-d-e
Shurite Meters, 61 Hamilton St., New Haven 6, Conn. a-d-e
Simpson Electric Co., Div. of American Gage & Machine Co., 5208 W. Kinzie St., Chicago 44, Ill. ADV. PG. 107. a-b-d-e-f
Varo Mfg. Co., Inc., Box 638, Garland, Texas. c-f
Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa. b-d-e
Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J. a-b-d-e-f

Fans

ELECTROMETERS

Applied Physics Corp., 30 W. Green St., Pasadena 1, Calif.
Baldwin Instrument Co., Ltd., Brooklands Works, Dartford, Kent
Beckman, Inc., Arnold O., 1020 Mission St., South Pasadena, Calif.
Cambridge Instrument Co., Inc., 3786 Grand Central Terminal, New York 17, N. Y.
Engineering Laboratories, Inc., 620 E. Fourth St., Tulsa 3, Okla.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
General Electric Co., Electronics Dept., Electronics Park, Syracuse, N. Y. ADV. PGS. 65 to 72.
Kelley-Koett Instrument Co., 936 York St., Cincinnati 14, Ohio. ADV. PG. Inside Back Cover.
Loudon Instruments, 5644 Lake Park Ave., Chicago 37, Ill.
Marconi Instruments, Ltd., 23–25 Beaver St., New York 4, N. Y.
Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne & Roberts Aves., Philadelphia 44, Pa. ADV. PG. 88.
Mullard Overseas Ltd., Century House, Shaftesbury Ave., London, W. C. 2.
Precision Scientific Co., 3737 Cortland Ave., Chicago, Ill.
Rawson Electrical Instrument Co., 114 Potter St., Cambridge 42, Mass.
Scientific Glass Apparatus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.
Special Instruments Laboratory, Inc., 1003 Highland Ave., Knoxville, Tenn. ADV. PG. 91.
Technical Associates, Inc., 3730 San Fernando Rd., Glendale 4, Calif. ADV. PG. 94.
Vacuum Electronic Engineering Co., 756 Third Ave., Brooklyn 32, N. Y.
Well Surveys, Inc., 624 E. 4th St., Tulsa 3, Okla.
Western Radiation Labs., 1107 W. 24th St., Los Angeles 27, Calif.

FANS—Cooling

Air Controls Inc., 2312 Superior Ave., Cleveland 14, Ohio
American Foundry & Furnace Co., Bloomington, Ill.
Buckeye Air Compressor Co., 414 Littell Ave., Dayton, Ohio
Buffalo Forge Co., 473 Broadway, Buffalo, N. Y.
Century Fan & Ventilating Co., 47 Cedar St., Stamford, Conn.
Chelsea Fan & Blower Co., Inc., 639 South Ave., Plainfield, N. J.
Clarage Fan Co., 719 Porter St., Kalamazoo, Mich.
Colloid Equipment Co., Inc., 48 Church St., New York, N. Y.
Commercialaire, Inc., 302 Pacific St., Brooklyn 2, N. Y.
Dayton Electric Mfg. Co., 748 W. Adams, Chicago, Ill.
Electric Blower Co., 350 Atlantic Ave., Boston, Mass.
Electrovent Fan & Mfg. Co., 812 W. Lake St., Chicago 7, Ill.
Emerson-Sack-Warner Corp., 92 Beverly, Boston, Mass.
Furbio Co., Hermansville, Mich.
General Mixing Equipment Co., 411 N. 3rd St., Philadelphia, Pa.
Harris, Inc., Machine Works, 61 S. E. Yamhill, Portland, Ore.
Houston Blow Pipe & Sheet Metal Works, P. O. Box 1692, Houston 1, Texas
International Engineering, Inc., 1200 Bolander Ave., Dayton, Ohio
Jay Mfg. Co., Oliver Bldg., Pittsburgh 22, Pa.
Mine Safety Appliances Co., Braddock, Thomas & Meade Sts., Pittsburgh 8, Pa.

Fans

Moore Co., 544 Westport Rd., Kansas City, Mo.
Mountain States Equipment Co., 1238 Speer Blvd., Denver, Colo.
Mowat Refrigerator, John, 1866 Folsom, San Francisco, Calif.
Nelson, Herman, Corp., Moline, Ill.
Rotron Mfg. Co., Inc., 7 Schoonmaker Lane, Woodstock, N. Y.
Sawyer Bailey Corp., P. O. Box 247, Station F, Buffalo 12, N. Y.
Small Motors, Inc., 2076 Elston Ave., Chicago 14, Ill.
Streeter-Amet Co., 4101 Ravenswood Ave., Chicago 13, Ill. ADV. PG. 110.
Trane Co., La Crosse, Wis.
United Blower Co., Inc., 193 Center St., New York, N. Y.
United States Air Conditioning Corp., Como Ave. SE at 33rd, Minneapolis 14, Minn.
Uno Ventilator Co., 565 Lincoln Ave., Cliftondale, Mass.
Western Blower Co., 1800 Airport Way, Seattle, Wash.
Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa.
Wind-Way Fan & Ventilator Co., 531 St. Joseph, New Orleans 12, La.

FANS—Exhaust

Air Controls Inc., 2312 Superior Ave., Cleveland 14, Ohio
Airmaster Corp., 4317 Ravenswood Ave., Chicago, Ill.
American Foundry & Furnace Co., Bloomington, Ill.
American Machine Products Co., Marshalltown, Iowa
Arex Co., 4317 Ravenswood Ave., Chicago 13, Ill.
Belke Mfg. Co., 947 N. Cicero Ave., Chicago 51, Ill.
Brundage Co., 502 North Park, Kalamazoo, Mich.
Buckeye Air Compressor Co., 414 Littell Ave., Dayton, Ohio
Buffalo Forge Co., 473 Broadway, Buffalo, N. Y.
Century Fan & Ventilating Co., 47 Cedar St., Stamford, Conn.
Chelsea Fan & Blower Co., Inc., 639 South Ave., Plainfield, N. J.
Clarage Fan Co., 719 Porter St., Kalamazoo, Mich.
Colloid Equipment Co., Inc., 48 Church St., New York, N. Y.
Commercialaire, Inc., 302 Pacific St., Brooklyn 2, N. Y.
Day Co., 820 3rd Ave. NE, Minneapolis, Minn.
Dayton Electric Mfg. Co., 748 W. Adams, Chicago, Ill.
De Vilbiss Co., 296 Phillips Ave., Toledo, Ohio
Electric Blower Co., 350 Atlantic Ave., Boston, Mass.
Electrovent Fan & Mfg. Co., 812 W. Lake St., Chicago 7, Ill.
Emerson-Sack-Warner Corp., 92 Beverly, Boston, Mass.
Furbio Co., Hermansville, Mich.
General Electric Co., Appliance & Merchandise Dept., Bridgeport 2, Conn. ADV. PGS. 65 to 72.
General Mixing Equipment Co., 411 N. 3rd St., Philadelphia, Pa.
Hirschman-Pohle Co., Inc., 15 Lent Ave., LeRoy, N. Y.
Houston Blow Pipe & Sheet Metal Works, P. O. Box 1692, Houston 1, Texas
Industrial Products Engineering Co., 44-26 Hunter St., Long Island City, N. Y.
International Engineering, Inc., 1200 Bolander Ave., Dayton, Ohio
Jacksonville Blow Pipe Co., Jacksonville, Fla.
Jordan & Co., Paul R., E. South & New Jersey, Indianapolis, Ind.
Joy Mfg. Co., Oliver Bldg., Pittsburgh 22, Pa.
Kernchen Co., 4317 Ravenswood Ave., Chicago 13, Ill.
Lehigh Fan & Blower Co., Allentown, Pa.

Filter Cloth

Master Mfg. Co., 813 W. Cabrini St., Chicago, Ill.
Mine Safety Appliances Co., Braddock, Thomas & Meade Sts., Pittsburgh 8, Pa.
Moore Co., 544 Westport, Rd., Kansas City, Mo.
Mountain States Equipment Co., 1238 Speer Blvd., Denver, Colo.
Nelson, Herman, Corp., Moline, Ill.
Newcomb-Detroit Co., 5741 Russell St., Detroit 11, Mich.
Northern Blower Co., 6427 Barberton Ave., Cleveland 2, Ohio
Pacific Foundry Co., Ltd., 3100 19th St., San Francisco, Calif.
Rotron Mfg. Co., Inc., 7 Schoonmaker Lane, Woodstock, N. Y.
Ruemelin Mfg. Co., 3961 N. Palmer St., Milwaukee, Wis.
Stromes Systems, Inc., 22nd St. & Sixth Ave., New York, N. Y.
Sutorbilt Corp., Sutorbilt Bldg., 2008 E. Slauson Ave., Los Angeles, Calif.
Trane Co., La Crosse, Wis.
Unit Roof Ventilator Corp., 1225 W. Mitchell St., Milwaukee 4, Wis.
United States Air Conditioning Corp., Como Ave. SE at 33rd, Minneapolis 14, Minn.
Uno Ventilator Co., 565 Lincoln Ave., Cliftondale, Mass.
Western Blower Co., 1800 Airport Way, Seattle, Wash.
Western Engineering & Mfg. Co., E. Washington & Staunton, Los Angeles, Calif.
Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa.
Wind-Way Fan & Ventilator Co., 531 St. Joseph, New Orleans 12, La.

FILM BADGES

Kelley-Koett Instrument Co., 936 York St., Cincinnati 14, Ohio. ADV. PG. Inside Back Cover.
St. John X-Ray Laboratory, Califon, N. J.
Samples Machine Co., A. M., 506 N. Central Ave., Knoxville, Tenn.
Technical Associates, Inc., 3730 San Fernando Rd., Glendale 4, Calif. ADV. PG. 94.
Tracerlab, Inc., 130 High St., Boston 10, Mass. ADV. PG. 74, 75.
Whitehead & Hoag Co., 272 Sussex Ave., Newark 7, N. J.

FILTER CLOTH—Cotton

Consolidated Siphon Supply Co., 24 Wooster St., New York, N. Y.
Filtration Engineers, Inc., Filtration Fabrics Div., 155 Oraton St., Newark 4, N. J.
Independent Filter Press, 230 48th St., Brooklyn, N. Y.
Modern Dust Bag Co., 547 Broadway, New York, N. Y.
Shriver & Co., Inc., 808 Hamilton St., Harrison, N. J.
Stanley Co., Inc., 401 Broadway, New York, N. Y.

FILTER CLOTH—Metallic

Consolidated Siphon Supply Co., 24 Wooster St., New York, N. Y.
Jelliff Mfg. Corp., C. O., 122 Pequot Ave., Southport, Conn.
Newark Wire Cloth Co., Newark, N. J.
Stanley Co., Inc., 401 Broadway, New York, N. Y.

FILTER CLOTH—Rubber

Stanley Co., Inc., 401 Broadway, New York, N. Y.

FILTER CLOTH—Synthetic Fibre

Filtration Engineers, Inc., Filtration Fabrics Div., 155 Oraton St., Newark 4, N. J.

Filter Discs

Independent Filter Press, 230 48th St., Brooklyn, N. Y.
Modern Dust Bag Co., 647 Broadway, New York, N. Y.
Shriver & Co., Inc., 808 Hamilton St., Harrison, N. J.
Stanley Co., Inc., 401 Broadway, New York, N. Y.

FILTER DISCS

Cellulo Co., Sandusky, Ohio
Consolidated Siphon Supply Co., 24 Wooster St., New York, N. Y.
Ertel Engineering Corp., 20 Front St., Kingston, N. Y.
Infilco, Inc., P. O. Box 5033, Tucson, Ariz.
Modern Dust Bag Co., 547 Broadway, New York, N. Y.
Special Instruments Laboratory, Inc., 1003 Highland Ave., Knoxville, Tenn. ADV. PG. 91.
Stanley Co., Inc., 401 Broadway, New York, N. Y.

FILTER PAPER

Angel & Co., Inc., H. Reeve, 52 Duane St., New York, N. Y.
Cellulo Co., Sandusky, Ohio
Consolidated Siphon Supply Co., 24 Wooster St., New York, N. Y.
Ertel Engineering Corp., 20 Front St., Kingston, N. Y.
Hollingsworth & Vose Co., E. Walpole, Mass.
Modern Dust Bag Co., 547 Broadway, New York, N. Y.
Scientific Glass Apparatus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.
Shriver & Co., Inc., 808 Hamilton St., Harrison, N. J.
Sparkler Mfg. Co., Mundelein, Ill.
Stanley Co., Inc., 401 Broadway, New York, N. Y.

FILTER PRESSES—Laboratory

Cellulo Co., Sandusky, Ohio
Consolidated Siphon Supply Co., 24 Wooster St., New York, N. Y.
Eimer & Amend, 635 Greenwich St., New York, N. Y.
Ertel Engineering Corp., 20 Front St., Kingston, N. Y.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Independent Filter Press, 230 48th St., Brooklyn, N. Y.
Shriver & Co., Inc., 808 Hamilton St., Brooklyn, N. Y.
Sparkler Mfg. Co., Mundelein, Ill.

FILTERS—Acid Resisting

Belke Mfg. Co., 947 N. Cicero Ave., Chicago 51, Ill.
Cellulo Co., Sandusky, Ohio
Consolidated Siphon Supply Co., 24 Wooster St., New York, N. Y.
Ertel Engineering Corp., 20 Front St., Kingston, N. Y.
Independent Filter Press, 230 48th St., Brooklyn, N. Y.
Infilco, Inc., P. O. Box 5033, Tucson, Ariz.
Knight, Maurice A., 171 Kelly Ave., Akron, Ohio
Modern Dust Bag Co., 547 Broadway, New York, N. Y.
Rulon Inc., Ralph V., Second & Pike Sts., Philadelphia, Pa.
Shriver & Co., Inc., 808 Hamilton St., Harrison, N. J.
Sparkler Mfg. Co., Mundelein, Ill.

FILTERS—Air

Buckeye Air Compressor Co., 414 Littell Ave., Dayton, Ohio
Conoflow Corp., 2100 Arch St., Philadelphia 3, Pa.
Day Co., 820 3rd Ave. NE, Minneapolis, Minn.
De Vilbiss Co., 296 Phillips Ave., Toledo, Ohio
Gas & Oil Industry Laboratories, Inc., 2 Paine Ave., Irvington 11, N. J.
Hannifin Corporation, 1194 S. Kilbourn Ave., Chicago 24, Ill.

Flooring

Houston Blow Pipe & Sheet Metal Works, P. O. Box 1692, Houston 1, Texas
Independent Filter Press, 230 48th St., Brooklyn, N. Y.
Industrial Products Engineering Co., 44–26 Hunter St., Long Island City, N. Y.
Johnson Corp., 809 Wood St., Three Rivers, Mich.
Modern Dust Bag Co., 547 Broadway, New York, N. Y.
Parsons Engineering Corp., 2547 E. 79th St., Cleveland, Ohio
Ruemelin Mfg. Co., 3961 N. Palmer St., Milwaukee, Wis.

FILTERS—Laboratory

Central Scientific Co., 1700 Irving Park Rd., Chicago 13, Ill.
Consolidated Siphon Supply Co., 24 Wooster St., New York, N. Y.
Eimer & Amend, 635 Greenwich St., New York, N. Y.
Ertel Engineering Corp., 20 Front St., Kingston, N. Y.
General Mixing Equipment Co., 411 N. 3rd St., Philadelphia, Pa.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Highland Engineering Co., 32 Holman Blvd., Hicksville, N. Y.
International Engineering, Inc., 1200 Bolander Ave., Dayton, Ohio
Scientific Glass Apparatus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.
Shriver & Co., Inc., 808 Hamilton St., Harrison, N. J.
Sparkler Mfg. Co., Mundelein, Ill.
Western Electro-Acoustic Labs., 204 S. Beverly Drive, Beverly Hills, Calif.

FILTERS—Wire Mesh

Consolidated Siphon Supply Co., 24 Wooster St., New York, N. Y.
Jelliff Mfg. Corp., C. O., 122 Pequot Ave., Southport, Conn.
Newark Wire Cloth Co., Newark, N. J.
Thomsen & Sons, L. C., Kenosha, Wis.

FLOORING—Acid-proof

American Mosaic & Tile Co., 33 E. Broadway, Louisville, Ky.
American-Olean Tile Co., Ninth St. & Kenilworth Ave., Lansdale, Pa.
Andel & Co., Inc., 5218 N. Kedzie Ave., Chicago, Ill.
Atlas Mineral Products Co., 121 Norman St., Mertztown, Pa.
Beck & Sons, Inc., I., 355 E. 20th St., New York 3, N. Y.
Conneaut Rubber & Plastic Co., Conneaut, Ohio
Electro Chemical Supply & Engineering Co., 750 Broad St., Emmans, Pa.
Hanley Co., Bradford, Pa.
Johns-Manville, 22 E. 40th St., New York 16, N. Y.
Knight, Maurice A., 171 Kelly Ave., Akron, Ohio
Lasting Products Co., 202 S. Franklintown Rd., Baltimore 23, Md.
Nukem Products Corp., 111 Colgate Ave., Buffalo 20, N. Y.
Rulon Inc., Ralph V., Second & Pike Sts., Philadelphia, Pa.
Safe Tread Co., Inc., 28 Vesey St., New York, N. Y.
Stonhard Co., 1306 Spring Garden St., Philadelphia 23, Pa.
Trinidad Brick & Tile Co., Trinidad, Colo.

FLOORING—Asphalt

Armstrong Cork Co., 1010 Concord St., Lancaster, Pa.

Fountains

Ceresit Waterproofing Corp., 3227 S. Shields Ave., Chicago 16, Ill.
Conneaut Rubber & Plastic Co., Conneaut, Ohio
Hachmeister-Inc., 2332 Forbes St., Pittsburgh 13, Pa.
Johns-Manville, 22 E. 40th St., New York 16, N. Y.
Lasting Products Co., 202 S. Franklintown Rd., Baltimore 23, Md.
Rulon Inc., Ralph V., Second & Pike Sts., Philadelphia, Pa.
Stonhard Co., 1306 Spring Garden St., Philadelphia 23, Pa.

FOUNTAINS—Eye

Precision Scientific Co., 3737 Cortland Ave., Chicago, Ill.

FURNACES—Laboratory

Cooper Co., D. C., 1467 S. Michigan Ave., Chicago, Ill.
Eclipse Fuel Engineering Co., 705 S. Main St., Rockford, Ill.
Eimer & Amend, 635 Greenwich St., New York, N. Y.
Electronic Engineering Corp., 624 Ridge Rd., Lyndhurst, N. J.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Hones, Inc., Charles A., 122 S. Grand Ave., Baldwin, N. Y.
National Research Corp., 70 Memorial Drive, Cambridge 42, Mass.
Precision Scientific Co., 3737 Cortland Ave., Chicago, Ill.
Scientific Glass Apparatus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.
Thermo Electric Mfg. Co., 480 W. Locust St., Dubuque, Ia.
Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa.

FURNITURE—Laboratory

Blickman, Inc., S., 7900 Gregory Ave., Weehawken, N. J. ADV. PG. 2.
Brooklyn Hospital Equipment Co., Inc., 196 Lexington Ave., New York, N. Y.
Buttling-Padgett Co., Inc., 830 Whittier, New York, N. Y.
Central Scientific Co., 1700 Irving Park Rd., Chicago 13, Ill.
Colloid Equipment Co., Inc., 48 Church St., New York, N. Y.
Doehler Metal Furniture Co., Inc., 194 Lexington Ave., New York, N. Y.
Eimer & Amend, 635 Greenwich St., New York, N. Y.
Electric Hotpack Co., Inc., 5035 Cottman Ave., Philadelphia, Pa.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Houston Blow Pipe & Sheet Metal Works, P. O. Box 1692, Houston 1, Texas
Kewanee Mfg. Co., 5083 S. Center St., Adrian, Mich.
Laboratory Construction Co., 1115 Holmes St., Kansas City, Mo.
Lyon Metal Products, Inc., 10 Montgomery St., Aurora, Ill.
Pacific Foundry Co., Ltd., 3100 19th St., San Francisco, Calif.
Pressteel Co., W. Garvey & Humboldt Ave., ElMonte, Calif.
Western Gold & Platinum Works, 589 Bryant St., San Francisco, Calif.

GAGES—Ionization

Baldwin Instrument Co., Ltd., Brooklands Works, Dartford, Kent.
Central Scientific Co., 1700 Irving Park Rd., Chicago 13, Ill.

Galvanometers

Distillation Products Industries, Div. of Eastman-Kodak Co., 755 Ridge Rd., W. Rochester 3, N. Y.
Eitel-McCullough, Inc., San Bruno, Calif.
El-Tronics, Inc., 2649 N. Howard St., Philadelphia 33, Pa. ADV. PG. 76, 77.
Heintz & Kaufman Div. of the Robert Dollar Co., 947 Broadway, Redwood City, Calif.
Litton Industries, San Carlos, Calif.
Manufacturers Engr. & Equip. Corp., Willow Grove, Pa.
National Research Corp., 70 Memorial Drive, Cambridge 42, Mass.
National Union Radio Corp., 350 Scotland Rd., Orange, N. J.
Optical Film Engineering Co., 2125 Cherry St., Philadelphia 3, Pa.
Process & Instruments, 60 Greenpoint Ave., Brooklyn 22, N. Y.
Radio Corp. of America, RCA Victor Div., Engineering Products Dept., Front & Cooper Sts., Camden, N. J. ADV. PG. 95.
Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa.

GAGES—Thickness, Radioactive

Baldwin Instrument Co., Ltd., Brooklands Works, Dartford, Kent
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
Tracerlab, Inc., 130 High St., Boston 10, Mass. ADV. PG. 74, 75.

GAGES—Vacuum

Automatic Temperature Control Co., Inc., 5206 Pulaski Ave., Philadelphia 44, Pa.
Central Scientific Co., 1700 Irving Park Rd., Chicago 13, Ill.
Clarke Instrument Corp., 910 King St., Silver Spring, Md.
Distillation Products Industries, Div. of Eastman-Kodak Co., 755 Ridge Rd. W., Rochester 3, N. Y.
Frank Bros. Mfg. Co., 10 W. Houston St., New York, N. Y.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
Hastings Instrument Co., Box 1275, Hampton, Va.
Marsh Instrument Co., Skokie, Ill.
National Research Corp., 70 Memorial Drive, Cambridge 42, Mass.
National Union Radio Corp., 350 Scotland Rd., Orange, N. J.
Optical Film Engineering Co., 2125 Cherry St., Philadelphia 3, Pa.
Pabst Engineering Equipment Co., Inc., Elizabeth, N. J.
Process & Instruments, 60 Greenpoint Ave., Brooklyn 22, N. Y.
Radio Corp. of America, RCA Victor Div., Engineering Products Dept., Front & Cooper Sts., Camden, N. J. ADV. PG. 95.
Scientific Glass Apparatus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.
Tagliabue Instruments Div. of Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.
Taylor Instrument Co., 95 Ames St., Rochester, N. Y.

GALVANOMETERS

Associated Research, Inc., 3758 W. Belmont, Chicago 18, Ill.
Baldwin Instrument Co., Ltd., Brooklands Works, Dartford, Kent.
Berndt-Bach, Inc., 7377 Beverly Rd., Los Angeles 36, Calif.

Gases

iddle Co., James G., 1316 Arch St., Philadelphia 7, a.
ambridge Instrument Co., Inc., 3786 Grand Central erminal, New York 17, N. Y.
entury Geophysical Corp., P. O. Box 6216, Tulsa 10, kla.
entral Scientific Co., 1700 Irving Park Rd., Chicago 3, Ill.
ngineering Laboratories, Inc., 620 E. Fourth St., ulsa 3, Okla.
-M Laboratories, Inc., 4313 N. Knox Ave., Chicago, l.
eneral Electric Co., Apparatus Dept., Schenectady 5, . Y. ADV. PGS. 65 to 72.
athaway Instrument Co., 1315 S. Clarkson St., enver 10, Colo.
eiland Research Corp., 130 E. 5th Ave., Denver , Colo.
B T Instruments, Inc., 441 Chapel St., New Haven , Conn.
arrell-Ash Co., 165 Neuberry St., Boston 16, Mass.
eeds & Northrup Co., 4970 Stenton Ave., Philadelhia 44, Pa.
larion Electrical Instrument Co., Manchester, N. H. DV. PG. 98.
leters, Inc., 915 Westfield Blvd., Indianapolis 20, nd.
awson Electrical Instrument Co., 114 Potter St., ambridge 42, Mass.
anborn Co., 39 Osborn St., Cambridge 39, Mass.
hallcross Mfg. Co., 10 Jackson Ave., Collingdale, a.
outhwestern Industrial Electronic Co., 2831 Post Oak d., Houston 19, Texas
impson Electric Co., Div. of American Gage & lachine Co., 5208 W. Kinzie St., Chicago 44, l. ADV. PG. 107.
hwing-Albert Instrument Co., 5351 Pulaski Ave., hiladelphia 44, Pa.
Vestinghouse Electric Corp., P. O. Box 868, Pittsurgh 30, Pa.
Veston Electrical Instrument Corp., 614 Frelinghuysen ve., Newark 5, N. J.

GASES—Inert

inde Air Products Co. Unit of Union Carbide & arbon Corp., 30 E. 42nd St., New York 17, N. Y.

GASES—Liquefied

merican Oxygen Service Corp., 600 Essex St., larrison, N. J.
mperial Gas Co., 3763 Ninth Ave., Los Angeles, alif.
ohnson & Jennings Co., 808 Addison Rd., Cleveland, hio
ittle, Inc., Arthur D., Cambridge 42, Mass.

GASES—Rare

merican Oxygen Service Corp., 600 Essex St., larrison, N. J.
inde Air Products Co., Unit of Union Carbide & arbon Corps., 30 E. 42nd St., New York 17, N. Y.
ullard Overseas Ltd., Century House, Shaftesbury ve., London, W. C. 2.
adiation Counter Laboratories, Inc., 1844 W. 21st t., Chicago 8, Ill. ADV. PG. 102.

GASKETS—Rubber

rmstrong Cork Co., 1010 Concord St., Lancaster, Pa.
rnst Water Column & Gage Co., 252 S. Livingston ve., Livingston, N. J.
ohns-Manville, 22 E. 40th St., New York 16, N. Y.
ullard Overseas Ltd., Century House, Shaftesbury ve., London, W. C. 2.
enn Fibre & Specialty Co., 2020 E. Westmoreland t., Philadelphia 3, Pa.

Geiger-Mueller Apparatus

U. S. Gasket Co., 602 N. 10th St., Camden, N. J.
U. S. Rubber Co., Electroforming Dept., 6602 Jefferson Ave., Detroit, Mich.

GASKETS—Silicone

Acushnet Rubber Co., New Bedford, Mass.
Connecticut Hard Rubber Co., New Haven, Conn.
Dow Chemical Co., Midland, Mich.
Dow Corning Corp., Midland, Mich.
General Electric Co., Chemical Dept., Pittsfield, Mass. ADV. PGS. 65 to 72.

GASKETS—Teflon

Ernst Water Column & Gage Co., 252 S. Livingston Ave., Livingston, N. J.
Johns-Manville, 22 E. 40th St., New York 16, N. Y.
Keystone Electronics Corp., 423 Broome St., New York 12, N. Y.
Penn Fibre & Speciality Co., 2020 E. Westmoreland St., Philadelphia 3, Pa.
U. S. Gasket Co., 602 N. 10th St., Camden, N. J.

GEIGER-MUELLER APPARATUS

Able Scientific Glass Apparatus Co., 6859 South Anthony Ave., Chicago 37, Ill. ADV. PG. 106.
Anton Electronic Labs., Inc., 1226-38 Flushing Ave., Brooklyn 6, N. Y. ADV. PG. 89.
Atomic Instrument Co., 84 Massachusetts Ave., Cambridge 39, Mass. ADV. PG. 101.
Baldwin Instrument Co., Ltd., Brooklands Works, Dartford, Kent
Chatham Electronics Corp., 475 Washington St., Newark 2, N. J.
Cinema-Television Ltd., Worsley Bridge Rd., London, S. E. 26
Cyclotron Specialties Co., Moraga 8, Calif.
Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.
Electronic Products Co., 111 E. 3rd St., Mt. Vernon, N. Y.
El-Tronics, Inc., 2649 N. Howard St., Philadelphia 33, Pa. ADV. PG. 76, 77.
Fisher Research Lab., Inc., 1961 University Ave., Palo Alto, Calif.
Frese Corp., Adolf., 116 W. 17th St., Los Angeles, Calif.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Kelley-Koett Instrument Co., 936 York St., Cincinnati 14, Ohio. ADV. PG. Inside Back Cover.
Menlo Research Laboratory, Menlo Park, Calif.
Mullard Overseas Ltd., Century House, Shaftesbury Ave., London, W. C. 2.
New London Instrument Co., P. O. Box 189, New London, Conn.
Nuclear Development Laboratory, P. O. Box 7034, Kansas City, Mo.
Nuclear Instrument & Chemical Corp., 223 W. Erie St., Chicago 10, Ill. ADV. PG. Back Cover.
Nuclear Measurements Corp., 3339 Central Ave., Indianapolis, Ind. ADV. PG. 96, 97.
Nuclear Research Corp., 112 S. 16th St., Philadelphia 2, Pa. ADV. PG. 109.
Nucleonic Corp of America, 497 Union St., Brooklyn 31, N. Y.
Phoenix Precision Instrument Co., 3803 N. 5th St., Philadelphia, Pa.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG 102.
Radioactive Products, Inc., 3201 E. Woodbridge St., Detroit 7, Mich.
Special Instruments Laboratory, Inc., 1003 Highland Ave., Knoxville, Tenn. ADV. PG. 91.
Standard Electronics Research Corp., 2 East End Ave., New York 21, N. Y.

Geiger-Mueller Tube Holders

Technical Associates, Inc., 3730 San Fernando Rd., Glendale 4, Calif. ADV. PG. 94.
Tracerlab Inc., 130 High St., Boston 10, Mass. ADV. PG. 74, 75.
Victoreen Instrument Co., 3800 Perkins Ave., Cleveland, Ohio. ADV. PG. Inside Front Cover.
Western Radiation Labs., 1107 W. 24th St., Los Angeles 27, Calif.
Wood Counter Laboratory, N., 5646 Harper Ave., Chicago 37, Ill. ADV. PG. 104.

GEIGER-MUELLER TUBE HOLDERS

Able Scientific Glass Apparatus Co., 6859 South Anthony Ave., Chicago 37, Ill. ADV. PG. 106.
Anton Electronic Labs., Inc., 1226–38 Flushing Ave., Brooklyn 6, N. Y. ADV. PG. 89.
Atomic Instrument Co., 84 Massachusetts Ave., Cambridge 39, Mass. ADV. PG. 101.
Cinema-Television Ltd., Worsley Bridge Rd., London, S. E. 26
Cyclotron Specialties Co., Moraga 8, Calif.
El-Tronics, Inc., 2649 N. Howard Sts., Philadelphia 33, Pa. ADV. PG. 76, 77.
Kelley-Koett Instrument Co., 936 York St., Cincinnati 14, Ohio. ADV. PG. Inside Front Cover.
Mullard Overseas Ltd., Century House, Shaftesbury Ave., London, W. C. 2.
Nuclear Instrument & Chemical Corp., 223 W. Erie St., Chicago 10, Ill. ADV. PG. Back Cover
Nuclear Research Corp., 112 S. 16th St., Philadelphia 2, Pa. ADV. PG. 109.
Nucleonic Corp. of America, 497 Union St., Brooklyn 31, N. Y.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Special Instruments Laboratory, Inc., 1003 Highland Ave., Knoxville, Tenn. ADV. PG. 91.
Technical Associates, Inc., 3730 San Fernando Rd., Glendale 4, Calif. ADV. PG. 94.
Tracerlab, Inc., 130 High St., Boston 10, Mass. ADV. PG. 74, 75.
Victoreen Instrument Co., 3800 Perkins Ave., Cleveland, Ohio. ADV. PG. Inside Front Cover.
Wood Counter Laboratory, N., 5646 Harper Ave., Chicago 37, Ill. ADV. PG. 104.

GEIGER-MUELLER TUBES—Self-Quenching

Able Scientific Glass Apparatus Co., 6859 South Anthony Ave., Chicago 37, Ill. ADV. PG. 106.
Amperex Electronic Corp., 25 Washington St., Brooklyn 1, N. Y.
Anton Electronic Labs., Inc, 1226–38 Flushing Ave., Brooklyn 6, N. Y. ADV. PG. 89.
Atomic Instrument Co., 84 Massachusetts Ave., Cambridge 39, Mass. ADV. PG. 101.
Chatham Electronics Corp., 475 Washington St., Newark 2, N. J.
Cinema-Television Ltd., Worsley Bridge Rd., London, S. E. 26
Cyclotron Specialties Co., Moraga 8, Calif.
Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.
Electronic Products Co., 111 E. 3rd St., Mt. Vernon, N. Y.
El-Tronics, Inc., 2649 N. Howard St., Philadelphia 33, Pa. ADV. PG. 76, 77.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Heintz & Kaufman Div. of The Robert Dollar Co., 947 Broadway, Redwood City, Calif.
Kelley-Koett Instrument Co., 936 York St., Cincinnati 14, Ohio. ADV. PG. Inside Back Cover.
Mullard Overseas Ltd., Century House, Shaftesbury Ave., London, W. C. 2.

Geiger-Mueller Tubes

North American Philips Co., Inc., 100 E. 42nd St., New York 17, N. Y.
Nuclear Development Laboratory, P. O. Box 7034, Kansas City, Mo.
Nuclear Instrument & Chemical Corp., 223 W. Erie St., Chicago 10, Ill. ADV. PG. Back Cover.
Nuclear Research Corp., 112 S. 16th St., Philadelphia 2, Pa. ADV. PG. 109.
Nucleonic Corp. of America, 497 Union St., Brooklyn 31, N. Y.
Radiation Counter Laboratories Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Radioactive Products, Inc., 3201 E. Woodbridge St., Detroit 7, Mich.
Raytheon Mfg. Co., Special Tube Section, 55 Chapel St., Newton 58, Mass. ADV. PG. 112.
Sylvania Electric Products, Inc., 1740 Broadway, New York 19, N. Y.
Technical Associates, Inc., 3730 San Fernando Rd., Glendale 4, Calif. ADV. PG. 94.
Tracerlab, Inc., 130 High St., Boston 10, Mass. ADV. PG. 74, 75.
Victoreen Instrument Co., 3800 Perkins Ave., Cleveland, Ohio. ADV. PG. Inside Front Cover.
Wood Counter Laboratory, N., 5646 Harper Ave., Chicago 37, Ill. ADV. PG. 104.

GEIGER-MUELLER TUBES—Thick Wall, Glass

Able Scientific Glass Apparatus Co., 6859 South Anthony Ave., Chicago 37, Ill. ADV. PG. 106.
Amperex Electronic Corp., 25 Washington St. Brooklyn 1, N. Y.
Anton Electronic Labs., Inc., 1226–38 Flushing Ave., Brooklyn 6, N. Y. ADV. PG. 89.
Atomic Instrument Co , 84 Massachusetts Ave., Cambridge 39, Mass. ADV. PG. 101.
Chatham Electronics Corp., 475 Washington St., Newark 2, N. J.
Cinema-Television Ltd., Worsley Bridge Rd., London, S. E. 26
Cyclotron Specialities Co., Moraga 8, Calif.
Eclipse-Pioneer Div., Bendix Aviation Corp. Teterboro, N. J.
Electronic Products Co., 111 E. 3rd St., Mt. Vernon, N. Y.
El-Tronics, Inc., 2649 N. Howard St., Philadelphia 33, Pa. ADV. PG. 76, 77.
Heintz & Kaufman Div. of The Robert Dollar Co., 947 Broadway, Redwood City, Calif.
Kelley-Koett Instrument Co., 936 York St., Cincinnati 14, Ohio. ADV. PG. Inside Front Cover.
North American Philips Co., Inc., 100 E. 42nd St., New York 17, N. Y.
Nuclear Development Laboratory, P. O. Box 7034, Kansas City, Mo.
Nuclear Instrument & Chemical Corp., 223 W. Erie St., Chicago 10, Ill. ADV PG. Back Cover.
Nuclear Research Corp., 112 S. 16th St., Philadelphia 2, Pa. ADV. PG. 109.
Nucleonic Corp. of America, 497 Union St., Brooklyn 31, N. Y.
Pioneer Electronics Corp., 2230 Broadway, Santa Monica, Calif.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Raytheon Mfg. Co., Special Tube Section, 55 Chapel St., Newton 58, Mass. ADV. PG. 112.
Sylvania Electric Products, Inc., 1740 Broadway, New York 19, N. Y.
Technical Associates, Inc., 3730 San Fernando Rd., Glendale 4, Calif. ADV. PG. 94.
Tracerlab, Inc., 130 High St., Boston 10, Mass. ADV. PG. 74, 75.
Victoreen Instrument Co., 3800 Perkins Ave., Cleveland, Ohio. ADV. PG. Inside Front Cover.
Wood Counter Laboratory, N., 5646 Harper Ave., Chicago 37, Ill. ADV. PG. 104.

Geiger-Mueller Tubes

GEIGER-MUELLER TUBES—Thick Wall, Metal

Able Scientific Glass Apparatus Co., 6859 South Anthony Ave., Chicago 37, Ill. ADV. PG. 106.
Amperex Electronic Corp., 25 Washington St., Brooklyn 1, N. Y.
Anton Electronic Labs., Inc., 1226–38 Flushing Ave., Brooklyn 6, N. Y. ADV. PG. 89.
Atomic Instrument Co, 84 Massachusetts Ave., Cambridge 39, Mass. ADV. PG. 101.
Ballantine Laboratories, Inc., Boonton, N. J.
Cyclotron Specialties Co., Moraga 8, Calif.
Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.
Electronic Products Co., 111 E. 3rd St., Mt. Vernon, N. Y.
El-Tronics, Inc., 2649 N. Howard St., Philadelphia 33, Pa. ADV. PG. 76, 77.
Engineering Laboratories, Inc., 620 E. Fourth St., Tulsa 3, Okla.
Kelley-Koett Instrument Co., 936 York St., Cincinnati 14, Ohio. ADV. PG. Inside Back Cover.
Mullard Overseas Ltd., Century House, Shaftesbury Ave., London, W. C. 2.
North American Philips Co., Inc., 100 E. 42nd St., New York 17, N. Y.
Nuclear Development Laboratory, P. O. Box 7034, Kansas City, Mo.
Nuclear Instrument & Chemical Corp. 223 W. Erie St., Chicago 10, Ill. ADV. PG. Back Cover.
Pioneer Electronics Corp., 2230 Broadway, Santa Monica, Calif.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Radioactive Products Inc., 3201 E. Woodbridge St., Detroit 7, Mich.
Sylvania Electric Products, Inc., 1740 Broadway, New York 19, N. Y.
Technical Associates, Inc., 3730 San Fernando Rd., Glendale 4, Calif. ADV. PG. 94.
Victoreen Instrument Co., 3800 Perkins Ave., Cleveland, Ohio. ADV. PG. Inside Front Cover.
Wood Counter Laboratory, N., 5646 Harper Ave., Chicago 37, Ill. ADV. PG. 104.

GEIGER-MUELLER TUBES—Thin Wall

Able Scientific Glass Apparatus Co., 6859 South Anthony Ave., Chicago 37, Ill. ADV. PG. 106.
Amperex Electronic Corp., 25 Washington St., Brooklyn 1, N. Y.
Anton Electronic Labs., Inc., 1226–38 Flushing Ave., Brooklyn 6, N. Y. ADV. PG. 89.
Atomic Instrument Co., 84 Massachusetts Ave., Cambridge 39, Mass. ADV. PG. 101.
Cinema-Television Ltd., Worsley Bridge Rd., London, S. E. 26
Cyclotron Specialties Co., Moraga 8, Calif.
Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.
Electronic Products Co., 111 E. 3rd St., Mt. Vernon, N. Y.
El-Tronics, Inc., 2649 N. Howard St., Philadelphia 33, Pa. ADV. PG. 76, 77.
Heintz & Kaufman Div. of The Robert Dollar Co., 947 Broadway, Redwood City, Calif.
Kelley-Koett Instrument Co., 936 York St., Cincinnati 14, Ohio. ADV. PG. Inside Back Cover.
Mullard Overseas Ltd., Century House, Shaftesbury Ave., London, W. C. 2.
North American Philips Co., Inc., 100 E. 42nd St., New York 17, N. Y.
Nuclear Development Laboratory, P. O. Box 7034, Kansas City, Mo.
Nuclear Instrument & Chemical Corp. 223 W. Erie St., Chicago 10, Ill. ADV. PG. Back Cover.
Nuclear Research Corp., 112 S. 16th St., Philadelphia 2, Pa. ADV. PG. 109.

Generators

Nucleonic Corp., of America, 497 Union St., Brooklyn 3, N. Y.
Pioneer Electronics Corp., 2230 Broadway, Santa Monica, Calif.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Raytheon Mfg. Co., Special Tube Section, 55 Chapel St., Newton 58, Mass. ADV. PG. 112.
Sylvania Electric Products, Inc., 1740 Broadway, New York 19, N. Y.
Technical Associates, Inc., 3730 San Fernando Rd., Glendale 4, Calif. ADV. PG. 94.
Tracerlab, Inc., 130 High St., Boston 10, Mass. ADV. PG. 74, 75.
Victoreen Instrument Co., 3800 Perkins Ave., Cleveland, Ohio. ADV. PG. Inside Front Cover.
Wood Counter Laboratory, N., 5646 Harper Ave., Chicago 37, Ill. ADV. PG. 104.

GEIGER-MUELLER TUBES—Thin Window

Able Scientific Glass Apparatus Co., 6859 South Anthony Ave., Chicago 37, Ill. ADV. PG. 106.
Amperex Electronic Corp., 25 Washington St., Brooklyn 1, N. Y.
Anton Electronic Labs., Inc., 1226–38 Flushing Ave., Brooklyn 6, N. Y. ADV. PG. 89.
Atomic Instrument Co., 84 Massachusetts Ave., Cambridge 39, Mass. ADV. PG. 101.
Cinema-Television Ltd., Worsley Bridge Rd., London, S. E. 26
Cyclotron Specialties Co., Moraga 8, Calif.
Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.
Electronic Products Co., 111 E. 3rd St., Mt. Vernon, N. Y.
El-Tronics, Inc., 2649 N. Howard St., Philadelphia 33, Pa. ADV. PG. 76, 77.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Heintz & Kaufman Div. of the Robert Dollar Co., 947 Broadway, Redwood City, Calif.
Kelley-Koett Instrument Co., 936 York St., Cincinnati 14, Ohio. ADV. PG. Inside Back Cover.
Mullard Overseas Ltd., Century House, Shaftesbury Ave., London, W. C. 2.
North American Philips Co., Inc., 100 E. 42nd St., New York 17, N. Y.
Nuclear Development Laboratory, P. O. Box 7034, Kansas City, Mo.
Nuclear Instrument & Chemical Corp., 223 W. Erie St., Chicago 10, Ill. ADV. PG. Back Cover.
Nuclear Research Corp., 112 S. 16th St., Philadelphia 2, Pa. ADV. PG. 109.
Nucleonic Corp., of America, 497 Union St., Brooklyn 3, N. Y.
Pioneer Electronics Corp., 2230 Broadway, Santa Monica, Calif.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Sylvania Electric Products, Inc., 1740 Broadway, New York 19, N. Y.
Technical Associates, Inc., 3730 San Fernando Rd., Glendale 4, Calif. ADV. PG. 94.
Tracerlab, Inc., 130 High St., Boston 10, Mass. ADV. PG. 74, 75.
Victoreen Instrument Co., 3800 Perkins Ave., Cleveland, Ohio. ADV. PG. Inside Front Cover.
Wood Counter Laboratory, N., 5646 Harper Ave., Chicago 37, Ill. ADV. PG. 104.

GENERATORS—Pulse

Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Berkeley Scientific Co., 6th & Nevin Ave., Richmond, Calif.
Berkshire Laboratories, P. O. Box 70, Concord, Mass.

Generators

Electronic Tube Corp., 1200 E. Mermaid Lane, Philadelphia 18, Pa.
Fiader, Inc., Fredric, North Tonawanda, N. Y.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Manufacturers Engr. & Equip. Corp., Willow Grove, Pa.
Measurements Corp., Boonton, N. J.
Nuclear Instrument & Chemical Corp., 223 W. Erie St., Chicago 10, Ill. Back Cover.
Potter Instrument Co., Inc., 115 Cutter Mill Rd., Great Neck, N. Y.
Radar Engineers, 110 University St., Seattle 1, Wash.
Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa.

GENERATORS—Signal

Daven Co., 191 Central Ave., Newark 4, N. J.
Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland, Ohio
Marconi Instruments Ltd., 23–25 Beaver St., New York 4, N. Y.
Precision Apparatus Co., Inc., 92–27 Horace Harding Blvd., Elmhurst, N. Y.
Simpson Electric Co., Div. of American Gage & Machine Co., 5208 W. Kinzie St., Chicago 44, Ill. ADV. PG. 107.
Varo Mfg. Co., Inc., Box 638, Garland, Texas

GLASS APPARATUS—Special

Able Scientific Glass Apparatus Co., 6859 South Anthony Ave., Chicago 37, Ill. ADV. PG. 106.
Dallons Labs., 5066 Santa Monica Blvd., Los Angeles, Calif.
Distillation Products Industries, Div. of Eastman-Kodak Co., 755 Ridge Rd. W., Rochester 3, N. Y.
Eberbach & Son Co., Inc., Ann Abror, Mich.
Fischer & Porter Co., 50 County Line Rd., Hatboro, Pa.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Glass Engineering Laboratories, Belmont, Calif.
Nucleonic Corp. of America, 497 Union St., Brooklyn 31, N. Y.
Phoenix Precision Instrument Co., 3803 N. 5th St., Philadelphia, Pa.
Process & Instruments, 60 Greenpoint Ave., Brooklyn 22, N. Y.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Sargent & Co., E. H., 4647 W. Foster Ave., Chicago 30, Ill.
Scientific Glass Apparatus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.
Special Glass Products Co., 2 W. 33rd St., New York, N. Y.
Wood Counter Laboratory, N., 5646 Harper Ave., Chicago 37, Ill. ADV. PG. 104.

GLASS—LABORATORY

Andel & Co., Inc., 5218 N. Kedzie Ave., Chicago, Ill.
Central Scientific Co., 1700 Irving Park Rd., Chicago 13, Ill.
Consolidated Siphon Supply Co., 24 Wooster St., New York, N. Y.
Fischer & Porter Co., 50 County Line Rd., Hatboro, Pa.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Phoenix Precision Instrument Co., 3803 N. 5th St., Philadelphia, Pa.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.

Heaters

Scientific Glass Apparatus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.
Special Glass Products Co., 2 W. 33rd St., New York, N. Y.

GLASSWARE—Laboratory

Armstrong Cork Co., 1010 Concord St., Lancaster, Pa.
Bache & Co., Semon, 636 Greenwich St., New York 14, N. Y.
Central Scientific Co., 1700 Irving Park Rd., Chicago 13, Ill.
Consolidated Siphon Supply Co., 24 Wooster St., New York, N. Y.
Eimer & Amend, 635 Greenwich St., New York, N. Y.
Fischer & Porter Co., 50 County Line Rd., Hatboro, Pa.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Phoenix Precision Instrument Co., 3803 N. 5th St., Philadelphia, Pa.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Scientific Glass Apparatus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.
Special Glass Products Co., 2 W. 33rd St., New York, N. Y.
Wood Counter Laboratory, N., 5646 Harper Ave., Chicago 37, Ill. ADV. PG. 104.

GLOVE BOXES

Blickman, Inc., S., 7900 Gregory Ave., Weehawken, N. J. ADV. PG. 2.
Brooklyn Hospital Equipment Co., Inc., 196 Lexington Ave., New York, N. Y.
Houston Blow Pipe & Sheet Metal Works, P. O. Box 1692, Houston 1, Texas
Industrial Products Engineering Co., 44–26 Hunter St., Long Island City, N. Y.
Kewanee Mfg. Co., 5083 S. Center St., Adrian, Mich.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.

GOGGLES—Acid and Dust Proof

American Optical Co., Southbridge, Mass.
Bausch & Lomb Optical Co., 635 St. Paul St., Rochester 2, N. Y.
Davis Emergency Equipment Co., Inc., 57 Halleck St., Newark, N. J.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Mine Safety Appliances Co., Braddock, Thomas & Meade Sts., Pittsburgh 8, Pa.
Safe-Gard Mfg. Co., 1826 Crawford Rd., Cleveland, Ohio.

HEATERS—Electronic

Allis-Chalmers Mfg. Co., 864 S. 70th St., Milwaukee 1, Wis.
American Electroneering Co., 2112 S. LaBrea Ave., Los Angeles, Calif.
Carnine & Bitter, 2332 Ontario Rd. NW, Washington 9, D. C.
Electronic Engineering Corp., 624 Ridge Rd., Lyndhurst, N. J.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
General Electric Co., Electronics Dept., Electronics Park, Syracuse, N. Y. ADV. PGS. 65 to 72.
Interelectronics Corp., 2432 Grand Concourse, New York, 57, N. Y.
Ieland Instruments, Ltd., 22–23 Millbank, London, S. W. 1
Marion Electrical Instrument Co., Manchester, N. H. ADV. PG. 98.
Mullard Overseas Ltd., Century House, Shaftesbury Ave., London, W. C. 2.

Heaters

Pioneer Electronic Corp., 2230 Broadway, Santa Monica, Calif.
Radio Corp. of America, RCA Victor Div., Engineering Products Dept., Front & Cooper Sts., Camden, N. J. ADV. PG. 95.
Spencer-Kennedy Labs., Inc., 186 Massachusetts Ave., Cambridge 39, Mass. ADV. PG. 92.
Stromes Systems, Inc., 22nd St. & Sixth Ave., New York, N. Y.
U. S. Rubber Co., Electroforming Dept., 6602 Jefferson Ave., Detroit, Mich.

HEATERS—Immersion

Acme Electric Heating Co., Inc., 1205 Washington St., Boston, Mass.
Belke Mfg. Co., 947 N. Cicero Ave., Chicago 51, Ill.
Colloid Equipment Co., Inc., 48 Church St., New York, N. Y.
Cooper Co., D. C., 1467 S. Michigan Ave., Chicago, Ill.
Cutler-Hammer, Inc., 412 N. 12th St., Milwaukee 1, Wis.
Eberbach & Son Co., Inc., Ann Arbor, Mich.
Eclipse Fuel Engineering Co., 705 S. Main St., Rockford, Ill.
Eimer & Amend, 635 Greenwich St., New York, N. Y.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
Hanes, Inc., Charles A., 122 S. Grand Ave., Baldwin, N. Y.
Industrial Engineering & Equipment Co., 711 S. Theresa, St. Louis 3, Mo.
Mullard Overseas Ltd., Century House, Shaftesbury Ave., London, W. C. 2.
Newcomb-Detroit Co., 5741 Russell St., Detroit 11, Mich.
Old Dominion Iron & Steel Corp., Bell Isle, Richmond, Va.
Precision Scientific Co., 3737 Cortland Ave., Chicago, Ill.
Rulon Inc., Ralph V., Second & Pike Sts., Philadelphia, Pa.
Scientific Glass Apparatus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.
Vulcan Electric Co., 88 Holten St., Danvers, Mass.
Watlow Electric Mfg. Co., 2256 Dickson St., St. Louis, Mo.
Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa.

HOODS—Chemical

Bar-Ray Products, Inc., 209 25th St., Brooklyn, N. Y.
Blickman, Inc., S., 7900 Gregory Ave., Weehawken, N. J. ADV. PG. 2.
Brooklyn Hospital Equipment Co., Inc., 196 Lexington Ave., New York, N. Y.
Buttling-Padgett Co., Inc., 830 Whittier, New York, N. Y.
Eimer & Amend, 635 Greenwich St., New York, N. Y.
Houston Blow Pipe & Sheet Metal Works, P. O. Box 1692, Houston, Texas
Industrial Products Engineering Co., 44–26 Hunter St., Long Island City, N. Y.
Kewanee Mfg. Co., 5083 S. Center St., Adrian, Mich.
Metal Products Corp., 48 W. 19th St., Weehawken, N. J.
Precision Scientific Co., 3737 Cortland Ave., Chicago, Ill.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Reidling & Olberg Metal Works, 10th & Chestnut, Chester, Pa.
Safe-Gard Mfg. Co., 1826 Crawford Rd., Cleveland, Ohio

Indicators

Unit Roof Ventilator Corp., 1225 W. Mitchell St., Milwaukee 4, Wis.
Uno Ventilator Co., 565 Lincoln Ave., Cliftondale, Mass.

HOSE—Acid Resisting

Consolidated Siphon Supply Co., 24 Wooster St., New York, N. Y.
Miller, Inc., Ray, 340 Dayton St., Newark, N. J.
Nukem Products Corp., 111 Colgate Ave., Buffalo 20, N. Y.
Republic Rubber Division of Lee Rubber & Tire Corp., Youngstown, Ohio
U. S. Rubber Co., Electroforming Dept., 6602 Jefferson Ave., Detroit, Mich.

HOSE—Metal, Flexible

Atlantic Metal Hose Co., 123 W. 64th St., New York 23, N. Y.
Consolidated Siphon Supply Co., 24 Wooster St., New York, N. Y.
Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.
Houston Blow Pipe & Sheet Metal Works, P. O. Box 1692, Houston 1, Texas

HOSE—Vacuum, Flexible

Distillation Products Industries, Div. of Eastman-Kodak Co., 755 Ridge Rd., W., Rochester 3, N. Y.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Houston Blow Pipe & Sheet Metal Works, P. O. Box 1692, Houston 1, Texas
Martindale Electric Co., Hird Ave., Cleveland 7, Ohio
Republic Rubber Division of Lee Rubber & Tire Corp., Youngstown, Ohio
U. S. Rubber Co., Electroforming Dept., 6602 Jefferson Ave., Detroit, Mich.

INDICATORS—Film Thickness

Austin Co., Special Devices Div., 19 Rector St., New York 6, N. Y.
Baldwin Instrument Co., Ltd., Brooklands Works, Dartford, Kent
Clarke Instrument Corp., 910 King St., Silver Spring, Md.
Engineering Laboratories, Inc., 620 E. Fourth St., Tulsa 3, Okla.
Fielden Instrument Corp., 2920 N. 4th St., Philadelphia 33, Pa.
Industrial Electronics, Inc., 8060 Wheeler St., Detroit 10, Mich.
Kelley-Koett Instrument Co., 936 York St., Cincinnati 14, Ohio. ADV. PG. Inside Back Cover.
Photobell Company, 116 Nassau St., New York 7, N. Y.
Standard Electronics Research Corp., 2 East End Ave., New York 21, N. Y.

INDICATORS—Fluid Flow

Austin Co., Special Devices Div., 19 Rector St., New York 6, N. Y.
Bailey Meter Co., 1044 Ivanhoe Road, Cleveland 10, Ohio
Carnine & Bittner, 2332 Ontario Rd., NW, Washington 9, D. C.
Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.
Engineering Laboratories, Inc., 620 E. Fourth St., Tulsa 3, Okla.
Ernst Water Column & Gage Co., 252 S. Livingston Ave., Livingston, N. J.
Fielden Instrument Corp., 2920 N. 4th St., Philadelphia 33, Pa.

Indicators

Fischer & Porter Co., 50 County Line Rd., Hatboro, Pa.
Foxboro Co., 86 Neponset Ave., Foxboro, Mass.
Gaveco Labs., Inc., 2 East End Ave., New York 21, N. Y.
Inflico, Inc., P. O. Box 5033, Tucson, Ariz.
Johnson & Jennings Co., 808 Addison Rd., Cleveland, Ohio
Lewis Steam Specialty & Valve Co., Cannon Ave. & Lewis St., Lansdale, Pa.
Miller, Inc., Ray, 340 Dayton St., Newark, N. J.
Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne & Roberts Aves., Philadelphia 44, Pa. ADV. PG. 88.
Nuclear Measurements Corp., 3339 Central Ave., Indianapolis, Ind. ADV. PG. 96, 97.
Phoenix Precision Instrument Co., 3803 N. 5th St., Philadelphia, Pa.
Precision Scientific Co., 3737 Cortland Ave., Chicago, Ill.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Radioactive Products, Inc., 3201 E. Woodbridge St., Detroit 7, Mich.
Schutte & Koerting Co., 1245 N. 12th St., Philadelphia, Pa.
Wood Counter Laboratory, N., 5646 Harper Ave., Chicago 37, Ill. ADV. PG. 104.

INDICATORS—Geiger Counter

Anton Electronic Labs., Inc., 1226–38 Flushing Ave., Brooklyn 6, N. Y. ADV. PG. 89.
Atomic Instrument Co., 84 Massachusetts Ave., Cambridge 39, Mass. ADV. PG. 101.
Austin Co., Special Devices Div., 19 Rector St., New York 6, N. Y.
Beckman Instruments, Inc., 820 Mission St., South Pasadena, Calif. ADV. PG. 85.
Chatham Electronics Corp., 475 Washington St., Newark 2, N. J.
Cyclotron Specialties Co., Moraga 8, Calif.
Douglas Radio Labs., 176 Norfolk Ave., Boston 19, Mass.
Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.
Electronic Products Co., 111 E. 3rd St., Mt. Vernon, N. Y.
El-Tronics, Inc., 2649 No. Howard St., Philadelphia 33, Pa. ADV. PG. 76, 77.
Engineering Laboratories, Inc., 620 E. Fourth St., Tulsa 3, Okla.
Fisher Research Lab., Inc., 1961 University Ave., Palo Alto, Calif.
General Electric Co., Electronics Dept., Electronics Park, Syracuse, N. Y. ADV. PGS. 65 to 72.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Kelley-Koett Instrument Co., 936 York St., Cincinnati 14, Ohio. ADV. PG. Inside Back Cover.
Menlo Research Laboratory, Menlo Park, Calif.
Mullard Overseas Ltd., Century House, Shaftesbury Ave., London, W. C. 2
Nuclear Development Laboratory, P. O. Box 7034, Kansas City, Mo.
Nuclear Instrument & Chemical Corp., 223 W. Erie St., Chicago 10, Ill. ADV. PG. Back Cover.
Nuclear Measurements Corp., 3339 Central Ave., Indianapolis, Ind. ADV. PG. 96, 97.
Nuclear Research Corp., 112 S. 16th St., Philadelphia 2, Pa. ADV. PG. 109.
Nucleonic Corp. of America, 497 Union St., Brooklyn 31, N. Y.
Potter Instrument Co., 115 Cutter Mill Rd., Great Neck, N. Y.
Radiation Counter Laboratories, Inc., 1844 W. 21 St., Chicago 8, Ill. ADV. PG. 102.
Radioactive Products, Inc., 3201 E. Woodbridge St., Detroit 7, Mich.

Indicators

Special Instruments Laboratory, Inc., 1003 Highland Ave., Knoxville, Tenn. ADV. PG. 91.
Standard Electronics Research Corp., 2 East End Ave., New York 21, N. Y.
Technical Associates, Inc., 3730 San Fernando Rd., Glendale 4, Calif. ADV. PG. 94.
Tracerlab, Inc., 130 High St., **Boston 10, Mass. ADV. PG. 74, 75.**
Victoreen Instrument Co., 3800 Perkins Ave., Cleveland, Ohio. ADV. PG. Inside Front Cover.
Western Radiation Labs., 1107 W. 24th St., Los Angeles 27, Calif.

INDICATORS—Humidity

Aeronautical Research Labs., General Mills, Inc., 2010 E. Hennepin Ave., Minneapolis 13, Minn. ADV. PG. 99.
Austin Co., Special Devices Div., 19 Rector St., New York 6, N. Y.
Cambridge Instrument Co., Inc., 3786 Grand Central Terminal, New York 17, N. Y.
Colloid Equipment Co., Inc., 48 Church St., New York, N. Y.
Cooper Co., D. C., 1467 S. Michigan Ave., Chicago, Ill.
Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.
Fielden Instrument Corp., 2920 N. 4th St., Philadelphia 33, Pa.
Foxboro Co., 86 Neponset Ave., Foxboro, Mass.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne & Roberts Aves., Philadelphia 44, Pa. ADV. PG. 88.
Polarad Electronics Corp., 100 Metropolitan Ave., Brooklyn 11, N. Y.
Powers Regulator Co., 2736 Greenview Ave., Chicago, Ill.
Serdex, Inc., 91 Cambridge St., Boston, Mass.
Tagliabue Instruments Div. of Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.
Taylor Instrument Co., 95 Ames St., Rochester, N. Y.
Thermo Instruments Co., 1066 El Camino Real, Belmont, Calif.
Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.

INDICATORS—Liquid Level

Airlectron, Inc., P. O. Box 151, Caldwell, N. J.
Associated Valve & Engineering Co., 1150 W. Marquette Rd., Chicago 21, Ill.
Austin Co., Special Devices Div., 19 Rector St., New York 6, N. Y.
Automatic Temperature Control Co., Inc., 5206 Pulaski Ave., Philadelphia 44, Pa.
Bailey Meter Co., 1044 Ivanhoe Rd., Cleveland 10, Ohio
Colloid Equipment Co., Inc., 48 Church St., New York, N. Y.
Conoflow Corp., 2100 Arch St., Philadelphia 3, Pa.
Coral Designs Div., Henry G. Dietz Co., 12–16 Astoria Blvd., Long Island City 2, N. Y.
Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.
Engineering Laboratories, Inc., 620 E. Fourth St., Tulsa 3, Okla.
Ernst Water Column & Gage Co., 252 S. Livingston Ave., Livingston, N. J.
Fielden Instrument Corp., 2920 N. 4th St., Philadelphia 33, Pa.
Fischer & Porter Co., 50 County Line Rd., Hatboro, Pa.
Fischer Research Lab., Inc., 1961 University Ave., Palo Alto, Calif.

Indicators

Foxboro Co., 86 Neponset Ave., Foxboro, Mass.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Infilco, Inc., P. O. Box 5033, Tucson, Ariz.
Johnson Corp., 809 Wood St., Three Rivers, Mich.
Johnson & Jennings Co., 808 Addison Rd., Cleveland, Ohio
Lumenite Electronic Co., 407 S. Dearborn St., Chicago 5, Ill.
Lunkenheimer Co., Beekman St. & Waverly Ave., Cincinnati, Ohio
Master's Inc., W. Irvin, Victor Pl. & N. Lake St., Burbank, Calif.
Mercoid Corp., 4201 Belmont Ave., Chicago 41, Ill.
Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne & Roberts Aves., Philadelphia 44, Pa. ADV. PG. 88.
Phoenix Precision Instrument Co., 3803 N. 5th St., Philadelphia, Pa.
Photobell Company, 116 Nassau St., New York 7, N. Y.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Radioactive Products, Inc., 3201 E. Woodbridge St., Detroit 7, Mich.
Tagliabue Instruments Div. of Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.
Taylor Instrument Co., 95 Ames St., Rochester, N. Y.
Thermo Instruments Co., 1066 El Camino Real, Belmont, Calif.

INDICATORS—Nuclear Radiation

Anton Electronic Labs., Inc., 1226–38 Flushing Ave., Brooklyn 6, N. Y. ADV. PG. 89.
Atomic Instrument Co., 84 Massachusetts Ave., Cambridge 39, Mass. ADV. PG. 101.
Austin Co., Special Devices Div., 19 Rector St., New York 6, N. Y.
Baldwin Instrument Co., Ltd., Brooklands Works, Dartford, Kent
Beckman, Inc., Arnold O., 1020 Mission St., South Pasadena, Calif.
Beckman Instruments, Inc., 820 Mission St., South Pasadena, Calif. ADV. PG. 85.
Cambridge Instrument Co., Inc., 3786 Grand Central Terminal, New York 17, N. Y.
Chatham Electronics Corp., 475 Washington St., Newark 2, N. J.
Clarkstan Corp., 11921 SW. Pico Blvd., Los Angeles 64, Calif.
Cyclotron Specialties Co., Moraga 8, Calif.
Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.
Electronic Products Co., 111 E. 3rd St., Mt. Vernon, N. Y.
El-Tronics, Inc., 2649 N. Howard St., Philadelphia 33, Pa. ADV. PG. 76, 77.
Ess Instrument Co., 98 S. Washington St., Bergenfield, N. J.
Fisher Research Lab., Inc., 1961 University Ave., Palo Alto, Calif.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
General Electric Co., Electronics Dept., Electronics Park, Syracuse, N. Y. ADV. PGS. 65 to 72.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Kelley-Koett Instrument Co., 936 York St., Cincinnati 14, Ohio. ADV. PG. Inside Back Cover.
Menlo Research Laboratory, Menlo Park, Calif.
Mullard-Overseas Ltd., Century House, Shaftesbury Ave., London, W. C. 2.
Nuclear Development Laboratory, P. O. Box 7034, Kansas City, Mo.
Nuclear Instrument & Chemical Corp., 223 W. Erie St., Chicago 10, Ill. ADV. PG. Back Cover.

Indicators

Nuclear Measurements Corp., 3339 Central Ave., Indianapolis, Ind. ADV. PG. 96, 97.
Nuclear Research Corp., 112 S. 10th St., Philadelphia 2, Pa. ADV. PG. 109.
Nucleonic Corp. of America, 497 Union St., Brooklyn 31, N. Y.
Potter Instrument Co., 115 Cutter Mill Rd., Great Neck, N. Y.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Radio Corp. of America, RCA Victor Div. Engineering Products Dept., Front & Cooper Sts., Camden, N. J. ADV. PG. 93.
Radioactive Products, Inc., 3201 E. Woodbridge Ave., Detroit 7, Mich.
Special Instruments Laboratory, Inc., 1003 Highland Ave., Knoxville, Tenn. ADV. PG. 91.
Standard Electronics Research Corp., 2 East End Ave., New York 21, N. Y.
Technical Associates, Inc., 3730 San Fernando Rd., Glendale 4, Calif. ADV. PG. 94.
Traceriab, Inc., 130 High St., Boston 10, Mass. ADV. PG. 74, 75.
Victoreen Instrument Co., 3800 Perkins Ave., Cleveland, Ohio. ADV. PG. Inside Front Cover.
Wayne-Kerr Laboratories, Ltd., New Malden, Surrey, England
Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa.
Wood Counter Laboratory, N., 5646 Harper Ave., Chicago 37, Ill. ADV. PG. 104.

INDICATORS—Pressure

Conoflow Corp., 2100 Arch St., Philadelphia 3, Pa.
Coral Designs Div., Henry G. Dietz Co., 12–16 Astoria Blvd., Long Island City 2, N. Y.
Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.
Electro Products Labs., Inc., 4501 N. Ravenswood, Chicago 6, Ill.
Fischer & Porter Co., 50 County Line Rd., Hatboro, Pa.
Foxboro Co., 86 Neponset Ave., Foxboro, Mass.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Mercoid Corp., 4201 Belmont Ave., Chicago 41, Ill.
Minneapolis-Honeywell Regulator Co., 2753 Fourth Ave. S., Minneapolis, Minn.
Phoenix Precision Instrument Co., 3803 N. 5th St., Philadelphia, Pa.
Tagliabue Instruments Div. of Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.
Taylor Instrument Co., 95 Ames St., Rochester, N. Y.

INDICATORS—Temperature

Austin Co., Special Devices Div., 19 Rector St., New York 6, N. Y.
Bailey Meter Co., 1044 Ivanhoe Rd., Cleveland 10, Ohio
Cambridge Instrument Co., Inc., 3786 Grand Central Terminal, New York 17, N. Y.
Carnine & Bitter, 2332 Ontario Rd. NW, Washington 9, D. C.
Colloid Equipment Co., Inc., 48 Church St., New York, N. Y.
Cutler-Hammer, Inc., 412 N. 12th St., Milwaukee 1, Wis.
Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.
Edison, Inc., Thomas A., Instrument Div., West Orange, N. J.
Fairchild Camera & Instrument Corp., 88–06 Van Wyck Blvd., Jamaica 1, N. Y.
Fischer & Porter Co., 50 County Line Rd., Hatboro Pa.
Fisher Research Lab., Inc., 1961 University Ave., Palo Alto, Calif.

Indicators

Foxboro Co., 86 Neponset Ave., Foxboro, Mass.
Friez Instrument Div., Bendix Aviation Corp., Baltimore 4, Md.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
Gordon Co., Claud S., 3000 S. Wallace St., Chicago 16, Ill.
Illinois Testing Labs., Inc., 420 N. LaSalle St., Chicago 10, Ill.
Industrial Controls, Inc., 525 N. Noble St., Chicago 22, Ill.
J B T Instruments, Inc., 441 Chapel St., New Haven 8, Conn.
Keckley Co., O. C., 400 Madison St., Chicago 6, Ill.
Leeds & Northrup Co., 4970 Stenton Ave., Philadelphia 44, Pa.
Lewis Engineering Co., 52 Rubber Ave., Naugatuck, Conn.
Marsh Instrument Co., Skokie, Ill.
Mercoid Corp., 4201 Belmont Ave., Chicago 41, Ill.
Meters, Inc., 915 Westfield Blvd., Indianapolis 20, Ind.
Minneapolis-Honeywell Regulator Co., 2753 Fourth Ave. S., Minneapolis, Minn.
Phoenix Precision Instrument Co., 3803 N. 5th St., Philadelphia, Pa.
Powers Regulator Co., 2736 Greenview Ave., Chicago, Ill.
Pyrometer Instrument Co., Inc., Bergenfield, N. J.
Richards Co., Inc., Arklay S., 12 Winchester St., Newton Highlands 61, Mass.
Serdex, Inc., 91 Cambridge St., Boston, Mass.
Tagliabue Instruments Div. of Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.
Taylor Instrument Co., 95 Ames St., Rochester, N. Y.
Thwing-Albert Instrument Co., 5351 Pulaski Ave., Philadelphia 44, Pa.
Sanborn Co., 39 Osborn St., Cambridge 39, Mass.
Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark, N. J.
Wheelco Instruments Co., 847 W. Harrison St., Chicago 7, Ill.

INDICATORS—Timing

Abrams Instrument Corp., 600–620 E. Schiawassee St., Lansing, Mich.
Airtectron, Inc., P. O. Box 151, Caldwell, N. J.
American Chronoscope Corp., 316 W. First St., Mt. Vernon, N. Y.
Atomic Instrument Co., 84 Massachusetts Ave., Cambridge 39, Mass. ADV. PG. 101.
Austin Co., Special Devices Div., 19 Rector St., New York 6, N. Y.
Automatic Temperature Control Co., Inc., 5206 Pulaski Ave., Philadelphia 44, Pa.
Carnine & Bitter, 2332 Ontario Rd. NW, Washington 9, D. C.
Colloid Equipment Co., Inc., 48 Church St., New York, N. Y.
Cramer Co., Inc., R. W., Box 13, Centerbrook, Conn.
El-Tronics, Inc., 2649 N. Howard St., Philadelphia 33, Pa. ADV. PG. 76, 77.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Gorrell & Gorrell, Haworth, N. J.
Lumenite Electronic Co., 407 S. Dearborn St., Chicago 5, Ill.
Nucleonic Corp. of America, 497 Union St., Brooklyn 31, N. Y.
Photobell Company, 116 Nassau St., New York 7, N. Y.
Potter Instrument Co., 115 Cutter Mill Rd., Great Neck, N. Y.
Special Instruments Laboratory, Inc., 1003 Highland Ave., Knoxville, Tenn. ADV. PG. 91.

Instrument Parts

Standard Electric Time Co., 89 Logan St., Springfield, Mass. ADV. PG. 86.
Tagliabue Instruments Div. of Weston Electric Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.
Taylor Instrument Co., 95 Ames St., Rochester, N. Y.
Tech Laboratories, Inc., Bergen & Edsall Blvds., Palisades Park, N. J.

INDICATORS—Vacuum

Austin Co., Special Devices Div., 19 Rector St., New York 6, N. Y.
Bailey Meter Co., 1044 Ivanhoe Rd., Cleveland 10, Ohio
Clarke Instrument Corp., 910 King St., Silver Spring, Md.
Distillation Products Industries, Div. of Eastman-Kodak Co., 755 Ridge Rd., W., Rochester 3, N. Y.
Foxboro Co., 86 Neponset Ave., Foxboro, Mass.
Hastings Instrument Co., Box 1275, Hampton, Va.
Litton Industries, San Carlos, Calif.
Marsh Instrument Co., Skokie, Ill.
Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne & Roberts Aves., Philadelphia 44, Pa. ADV. PG. 88.
National Research Corp., 70 Memorial Drive, Cambridge 42, Mass.
National Union Radio Corp., 350 Scotland Rd., Orange, N. J.
Optical Film Engineering Co., 2125 Cherry St., Philadelphia 3, Pa.
Process & Instruments, 60 Greenpoint Ave., Brooklyn 22, N. Y.
Taylor Instrument Co., 95 Ames St., Rochester, N. Y.

INSTRUMENT PARTS—Precision

Abrams Instrument Corp., 600–620 E. Schiawassee St., Lansing, Mich.
Alden Products Co., 117 N. Main St., Brockton 64, Mass.
American Laubscher Corp., 333 W. 52nd St., New York 19, N. Y.
Arma Corp., 254 36th St., Brooklyn 32, N. Y.
Automatic Temperature Control Co., Inc., 5206 Pulaski Ave., Philadelphia 44, Pa.
Baldwin Instrument Co., Ltd., Brooklands Works, Dartford, Kent
Beckman & Whitley, Inc., 985 San Carlos Ave., San Carlos, Calif.
Bradley Labs., Inc., 82 Meadow St., New Haven 10, Conn.
Brown Electro-Measurement Corp., 4637 SE Hawthorne Blvd., Portland 15, Oregon
Buhl Optical Co., 1009 Beech Ave., Pittsburgh 12, Pa.
Cambridge Instrument Co., Inc., 3786 Grand Central Terminal, New York 17, N. Y.
Carnine & Bitter, 2332 Ontario Rd., NW, Washington 9, D. C.
Chandler & Stedman, 398 Newton St., Waltham 54, Mass.
Cinema Engineering Co., 1510 W. Verdugo Ave., Burbank, Calif.
Conoflow Corp., 2100 Arch St., Philadelphia 3, Pa.
Eberbach & Son Co., Inc., Ann Arbor, Mich.
Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.
Farrand Optical Co., Inc., Bronx Blvd. at 238th St., New York 70, N. Y.
Ferner Co., R. Y., 110 Pleasant St., Malden, Mass.
Foxboro Co., 86 Neponset Ave., Foxboro, Mass.
Gale Dorothea Mechanisms, 37–61 85th St., Jackson Heights, L. I., N. Y.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Heinicke Instrument Corp., 315 Alexander St., Rochester 4, N. Y.

Instruments

Houston Technical Labs., 2424 Branard, Houston 6, Texas
Industrial Controls, Inc., 525 N. Noble St., Chicago 22, Ill.
Instrument Laboratories, 315 W. Walton Place, Chicago 10, Ill.
Jarrell-Ash Co., 165 Neuberry St., Boston 16, Mass.
Keystone Electronics Corp., 423 Broome St., New York 12, N. Y.
Leland Instruments, Ltd., 22–23 Millbank, London, S. W. 1.
Marconi Instruments, Ltd., 23–25 Beaver St., New York 4, N. Y.
Maurer, Inc., J. A., 37–01 31st St., Long Island City, N. Y.
Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne & Roberts Aves., Philadelphia 44, Pa. ADV. PG. 88.
Nuclear Measurements Corp., 3339 Central Ave., Indianapolis, Ind. ADV. PG. 96, 97.
Phoenix Precision Instrument Co., 3803 N. 5th St., Philadelphia, Pa.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Sargent & Co., E. H., 4647 W. Foster Ave., Chicago 30, Ill.
Serdex, Inc., 91 Cambridge St., Boston, Mass.
Special Instruments Laboratory, Inc., 1003 Highland Ave., Knoxville, Tenn. ADV. PG. 91.
Stephens Mfg. Corp., 8538 Warner Drive, Culver City, Calif.
Taylor Instrument Co., 95 Ames St., Rochester, N. Y.
Thwing-Albert Instrument Co., 5351 Pulaski Ave., Philadelphia 44, Pa.
Vallorbs Jewel Co., Lancaster, Pa.

INSTRUMENTS—Graphic Recording

Alfax Paper & Engineering Co., 40 Riverside Ave., Brockton 27, Mass. ADV. PG. 100.
Austin Co., Special Devices Div., 19 Rector St., New York 6, N. Y.
Bailey Meter Co., 1044 Ivanhoe Rd., Cleveland 10, Ohio
Beckman & Whitley, Inc., 985 San Carlos Ave., San Carlos, Calif.
Brush Development Co., 3405 Perkins Ave., Cleveland 14, Ohio
Consolidated Engineering Corp., 620 N. Lake Ave., Pasadena 4, Calif. ADV. PG. 82.
Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.
Edin Co., Inc., 207 Main St., Worcester, Mass.
Electronic Associates, Inc., Long Branch, N. J.
Farrand Optical Co., Inc., Bronx Blvd. at 238th St., New York 70, N. Y.
Fielden Instrument Corp., 2920 N. 4th St., Philadelphia 33, Pa.
Fischer & Porter Co., 50 County Line Rd., Hatboro, Pa.
Foxboro Co., 86 Neponset Ave., Foxboro, Mass.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
Gorrell & Gorrell, Haworth, N. J.
Hathaway Instrument Co., 1315 S. Clarkson St., Denver 10, Colo.
Industrial Science Associates, 542 Fifth Ave., New York 19, N. Y.
Jarrell-Ash Co., 165 Neuberry St., Boston 16, Mass.
Leeds & Northrup Co., 4970 Stenton Ave., Philadelphia 44, Pa.
Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne & Roberts Aves., Philadelphia 44, Pa. ADV. PG. 88.
Potter Instrument Co., 115 Cutter Mill Rd., Great Neck, N. Y.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.

Ionization Chambers

Rahm Instruments, Inc., 12 West Broadway, New York 7, N. Y.
Sanborn Co., 39 Osborn St., Cambridge 39, Mass.
Serdex, Inc., 91 Cambridge St., Boston, Mass.
Servo-Tek Products Co., 4 Godwin Ave., Paterson, N. J.
Sound Apparatus Co., Stirling, N. J.
Southwestern Industrial Electronic Co., 2831 Post Oak Rd., Houston 19, Texas
Special Instruments Laboratory, Inc., 1003 Highland Ave., Knoxville, Tenn. ADV. PG. 91.
Taylor Instrument Co., 95 Ames St., Rochester, N. Y.
Thwing-Albert Instrument Co., 5351 Pulaski Ave., Philadelphia 44, Pa.
Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa.
Wheelco Instruments Co., 847 W. Harrison St., Chicago 7, Ill.

INSULATORS—Fused Quartz

General Electric Co., Lamp Dept., Nela Park, Cleveland 12, Ohio ADV. PGS. 65 to 72.
Thwing-Albert Instrument Co., 5351 Pulaski Ave., Philadelphia 44, Pa.

IONIZATION CHAMBERS

Anton Electronic Labs., Inc., 1226–38 Flushing Ave., Brooklyn 6, N. Y. ADV. PG. 89.
Applied Physics Corp., 30 W. Green St., Pasadena 1, Calif.
Atomic Instrument Co., 84 Massachusetts Ave., Cambridge 39, Mass. ADV. PG. 101.
Baldwin Instrument Co., Ltd., Brooklands Works, Dartford, Kent
Beckman, Inc., Arnold O., 1020 Mission St., South Pasadena, Calif.
Cambridge Instrument Co., Inc., 3786 Grand Central Terminal, New York 17, N. Y.
Chatham Electronics Corp., 475 Washington St., Newark 2, N. J.
Electronic Products Co., 111 E. 3rd St., Mt. Vernon, N. Y.
El-Tronics, Inc., 2649 N. Howard St., Philadelphia 33, Pa. ADV. PG. 76, 77.
Engineering Laboratories, Inc., 620 E. Fourth St., Tulsa 3, Okla.
Espey Mfg. Co., Inc., 528 E. 72nd St., New York 21, N. Y.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
General Electric Co., Electronics Dept., Electronics Park, Syracuse, N. Y. ADV. PGS. 65 to 72.
General Electric X-Ray Corp., 4855 Electric Ave., Milwaukee, Wis. ADV. PG. 73.
Interelectronics Corp., 2432 Grand Concourse, New York 57, N. Y.
Kelley-Koett Instrument Co., 936 York St., Cincinnati 14, Ohio. ADV. PG. Inside Back Cover.
Loudon Instruments, 5644 Lake Park Ave., Chicago 37, Ill.
Mullard Overseas Ltd., Century House, Shaftesbury Ave., London, W. C. 2.
Nuclear Instrument & Chemical Corp., 223 W. Erie St., Chicago 10, Ill. ADV. PG. Back Cover.
Nuclear Measurements Corp., 3339 Central Ave., Indianapolis, Ind. ADV. PG. 96, 97.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Radioactive Products, Inc., 3201 E. Woodbridge St., Detroit 7, Mich.
Special Instrument Laboratory, Inc., 1003 Highland Ave., Knoxville, Tenn. ADV. PG. 91.
Sylvania Electric Products, Inc., 1740 Broadway, New York 19, N. Y.
Technical Associates, Inc., 3730 San Fernando Rd., Glendale 4, Calif. ADV. PG. 94.
Tracerlab, Inc., 130 High St., Boston 10, Mass. ADV. PG. 74, 75.

Isotope-Labeled Compounds

Victoreen Instrument Co., 3800 Perkins Ave., Cleveland, Ohio. ADV. PG. Inside Front Cover.
Wayne-Kerr Laboratories, Ltd., New Malden, Surrey, England
Well Surveys, Inc. 624 E. 4th St., Tulsa 3, Okla.
Western Radiation Labs., 1107 W. 24th St., Los Angeles 27, Calif.
Wood Counter Laboratory, N., 5646 Harper Ave., Chicago 37, Ill. ADV. 104.

ISOTOPE-LABELED COMPOUNDS

Abbott Laboratories, North Chicago, Ill.
Isotopes Division of AEC, Oak Ridge, Tenn.
Radioactive Products, Inc., 3201 E. Woodbridge St., Detroit 7, Mich.
Southern Research Institute, Birmingham, Ala.
Technical Associates, Inc., 3730 San Fernando Rd., Glendale 4, Calif. ADV. PG. 94.
Texas Research Foundation, Renner, Texas.
Tracerlab, Inc., 130 High St., Boston 10, Mass. ADV. PG. 74, 75.
United States Testing Co., Hoboken, N. J.

ISOTOPES—Radioactive

Abbott Laboratories, North Chicago, Ill.
Baldwin Instrument Co., Ltd., Brooklands Works, Dartford, Kent
Eldorado Mining & Refining Ltd., Ottawa, Ontario, Canada
Fleischman, Burd & Co., Inc., 22 W. 48th St., New York 19, N. Y.
Isotopes Division of AEC, Oak Ridge, Tenn.
National Research Council of Canada, Isotopes Branch, Chalk River, Ontario, Canada
Radioactive Products, Inc., 3201 E Woodbridge St., Detroit 7, Mich.
St. John X-Ray Laboratory, Califon, N. J.
Technical Associates, Inc., 3730 San Fernando Rd., Glendale 4, Calif. ADV. PG. 94.
Tracerlab, Inc., 130 High St., Boston 10, Mass. ADV. PG. 74, 75.
U. S. Radium Corp., 535 Pearl St., New York 7, N. Y.

LAMPS—Neon Glow

Alden Products Co., 17 N. Main St., Brockton 64, Mass.
Dial Light Co. of America, Inc., 900 Broadway, New York 3, N. Y.
General Electric Co., Lamp Dept., Nela Park, Cleveland 12, Ohio. ADV. PGS. 65 to 72.
Sylvania Electric Products, Inc., 1740 Broadway, New York 19, N. Y.
Tung-Sol Lamp Works, Inc., 95 Eighth Ave., Newark 4, N. J.
Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa.

LEAD GLASS

Penberthy Instrument Co., Hi-D Division, 666 Adams St., Seattle 8, Wash. ADV. PG. 106.

LEAD SHIELDING EQUIPMENT

Alpha Metals, Inc., 363 Hudson Ave., Brooklyn 1, N. Y.
Andel & Co., Inc., 5218 N. Kedzie Ave., Chicago, Ill.
Bar-Ray Products, Inc., 209 25th St., Brooklyn, N. Y.
Blickman, Inc., S., 7900 Gregory Ave., Weehawken, N. J. ADV. PG. 2.
Buffalo Weaving & Belting Co., Buffalo 7, N. Y.
El-Tronics, Inc., 2649 N. Howard St., Philadelphia 33, Pa. ADV. PG. 76, 77.
General Electric X-Ray Corp., 4855 Electric Ave., Milwaukee, Wis. ADV. PG. 73.
Hollingshead Corp., R. M., Cocoon Engineering Div., 840 Cooper St., Camden, N. J.

Manometers

Keller Products, Inc., Manchester, N. H.
Kelley-Koett Instrument Co., 936 York St., Cincinnati 14, Ohio. ADV. PG. Inside Back Cover.
Mullard Overseas Ltd., Century House, Shaftesbury Ave., London, W. C. 2.
Nuclear Research Corp., 112 S. 16th St., Philadelphia 2, Pa. ADV. PG. 109.
Nucleonic Corp. of America, 497 Union St., Brooklyn 31, N. Y.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Rothband & Co., W. S., Bent St., Manchester 8, England
St. John X-Ray Laboratory, Califon, N. J.
Special Instruments, Laboratory, Inc., 1003 Highland Ave., Knoxville, Tenn. ADV. PG. 91.
Technical Associates, Inc., 3730 San Fernando Rd., Glendale 4, Calif. ADV. PG. 94.
Tracerlab, Inc., 130 High St., Boston 10, Mass. ADV. PG. 74, 75.

MACHINES—Electronic Computing

Alden Products Co., 117 N. Main St., Brockton 64, Mass.
American Electroneering Co., 2112 S. LaBrea Ave., Los Angeles, Calif.
Arlington Electric Products, Inc., 500 W. 52nd St., New York 19, N. Y.
Atomic Instrument Co., 84 Massachusetts Ave., Cambridge 39, Mass. ADV. PG. 101.
Austin Co., Special Devices Div., 19 Rector St., New York 6, N. Y.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Carnine & Bitter, 2332 Ontario Rd. NW, Washington 9, D. C.
Consolidated Engineering Corp., 620 N. Lake Ave., Pasadena 4, Calif. ADV. PG. 82.
Davies Laboratories, Inc., 4705 Queensbury Rd., Riverdale, Md.
Electronic Associates, Inc., Long Branch, N. J.
Engineering Research Associates, Inc., 1902 W. Minnehaha Ave., St. Paul 4, Minn.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
Loral Electronics Corp., 794 E. 140th St., New York 54, N. Y.
Marconi Instruments, Ltd., 23–25 Beaver St., New York 4, N. Y.
Potter Instrument Co., 115 Cutter Mill Rd., Great Neck, N. Y.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Transmitter Equipment Mfg. Co., Inc., 345 Hudson St., New York 14, N. Y.

MAGNETS

Bethlehem Steel Co., Bethlehem, Pa.
Little, Inc., Arthur D., Cambridge 42, Mass.

MANOMETERS—U-Type

Coral Designs Div., Henry G. Dietz Co., 12–16 Astoria Blvd., Long Island City 2, N. Y.
Dallons Labs., 5066 Santa Monica Blvd., Los Angeles, Calif.
Distillation Products Industries, Div., of Eastman-Kodak Co., 755 Ridge Rd., W., Rochester 3, N. Y.
Fielden Instrument Corp., 2920 N. 4th St., Philadelphia 33, Pa.
Frese Corp., Adolf, 116 W. 17th St. Los Angeles, Calif.
Gorrell & Gorrell, Haworth, N. J.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Sargent & Co., E. H., 4647 W. Foster Ave., Chicago 30, Ill.

Masks

Scientific Glass Apparatus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.
Thermo Instruments Co., 1066 El Camino Real, Belmont, Calif.

MASKS—Dust, Fume, Gas, Smoke, etc.

American Optical Co., Southbridge, Mass.
Associated Research, Inc., 3758 W. Belmont, Chicago 18, Ill.
Davis Emergency Equipment Co., Inc., 57 Halleck St., Newark, N. J.
De Vilbiss Co., 296 Phillips Ave., Toledo, Ohio
Industrial Products Engineering Co., 44–26 Hunter St., Long Island City, N. Y.
Martindale Electric Co., Hird Ave., Cleveland 7, Ohio
Mine Safety Appliances Co., Braddock, Thomas & Meade Sts., Pittsburgh 8, Pa.
Safe-Gard Mfg. Co., 1826 Crawford Rd., Cleveland, Ohio
U. S. Rubber Co., Electroforming Dept., 6602 Jefferson Ave., Detroit, Mich.
Willson Products, Inc., Reading, Pa.

MEGOHMMETERS

Beta Electric Corp., 333 E. 103rd St., New York 29, N. Y.
Biddle Co., James G., 1316 Arch St., Philadelphia 7, Pa.
Douglas Radio Labs., 176 Norfolk Ave., Boston 19, Mass.
El-Tronics, Inc., 2649 N. Howard St., Philadelphia 33, Pa. ADV. PG. 76, 77.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Kelley-Koett Instrument Co., 936 York St., Cincinnati 14, Ohio. ADV. PG. Inside Back Cover.
Leland Instruments, Ltd., 22–23 Millbank, London, S. W. 1.
MacLeod & Hanopol, Inc., 10 Joiner St., Charlestown 29, Mass.
Meters, Inc., 915 Westfield Blvd., Indianapolis 20, Ind.
Mullard Overseas Ltd., Century House, Shaftesbury Ave., London, W. C. 2.
Precision Apparatus Co., Inc., 92–27 Horace Harding Blvd., Elmhurst, N. Y.
Radio Corp. of America, RCA Victor Div., Tube Dept., 415 S. Fifth St., Harrison, N. J. ADV. PG. 83, 87.
Radio Frequency Labs., Inc., Boonton 2, N. J.
Shaltcross Mfg. Co., 10 Jackson Ave., Collingdale, Pa.
Southwestern Industrial Electronic Co., 2831 Post Oak Rd., Houston 19, Texas
Stitcht Co., Inc., Herman H., 27 Park Place, New York 7, N. Y.
Tech Laboratories, Inc., Bergen and Edsall Blvds., Palisades Park, N. J.
Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa.

METALS

Aluminum

Aluminum Co. of America, 2156 Gulf Bldg., Pittsburgh, Pa.
Beck & Sons, Inc., I., 355 E. 20th St., New York 3, N. Y.
Belmont Smelting & Refining Works, Inc., 322 Belmont Ave., Brooklyn, N. Y.
Federated Metals Div., American Smelting & Refining Co., 120 Broadway, New York 5, N. Y.
Imperial Bronze & Mfg. Co., Jellico, Tenn.
Kaiser Aluminum & Chemical Sales, Inc., 1924 Broadway, Oakland 12, Calif.
Miller, Inc., Ray, 340 Dayton St., Newark, N. J.

Metals

Revere Copper & Brass, Inc., 230 Park Ave., New York 17, N. Y.

Alnico

Arnold Engineering Co., Marengo, Ill.

Antimony

Alpha Metals, Inc., 363 Hudson Ave., Brooklyn 1, N. Y.
Belmont Smelting & Refining Works, Inc., 322 Belmont Ave., Brooklyn, N. Y.
Federated Metals Div., American Smelting & Refining Co., 120 Broadway, New York 5, N. Y.
Jarrell-Ash Co., 165 Neuberry St., Boston 16, Mass.
National Lead Co., 111 Broadway, New York 6, N. Y.

Arsenic

Belmont Smelting & Refining Works, Inc., 322 Belmont Ave., Brooklyn, N. Y.
Federated Metals Div., American Smelting & Refining Co., 120 Broadway, New York 5, N. Y.
Jarrell-Ash Co., 165 Neuberry St., Boston 16, Mass.

Barium

Jarrell-Ash Co., 165 Neuberry St., Boston 16, Mass.

Beryllium and Beryllium Alloys

American Silver Co., Inc., 36–07 Prince St., Flushing, N. Y.
Belmont Smelting & Refining Works, Inc., 322 Belmont Ave., Brooklyn, N. Y.
Brush Beryllium Co., The, 4301 Perkins Ave., Cleveland 3, Ohio
Gas & Oil Industry Laboratories, Inc., 2 Paine Ave., Irvington 11, N. J.
Jarrell-Ash Co., 165 Neuberry St., Boston 16, Mass.
Mallory & Co., Inc., P. R., 3029 E. Washington St., Indianapolis 6, Ind.
Sherman & Co., 36–07 Prince St., Flushing, N. Y.

Brass and Bronze

American Oxygen Service Corp., 600 Essex St., Harrison, N. J.
American Silver Co., Inc., 36–07 Prince St., Flushing N. Y.
Belmont Smelting & Refining Works, Inc., 322 Belmont Ave., Brooklyn, N. Y.
Federated Metals Div., American Smelting & Refining Co., 120 Broadway, New York 5, N. Y.
Imperial Bronze & Mfg. Co., Jellico, Tenn.
Jarrell-Ash Co., 165 Neuberry St., Boston 16, Mass.
Mallory & Co., Inc., P. R., 3029 E. Washington St., Indianapolis 6, Ind.
Revere Copper & Brass, Inc., 230 Park Ave., New York 17, N. Y.

Cadmium

Belmont Smelting & Refining Works, Inc., 322 Belmont Ave., Brooklyn, N. Y.
Eagle-Picher Co., Cincinnati, Ohio
Federated Metals Div., American Smelting & Refining Co., 120 Broadway, New York 5, N. Y.
Jarrell-Ash Co., 165 Neuberry St., Boston 16, Mass.

Cerium

Belmont Smelting & Refining Works, Inc., 322 Belmont Ave., Brooklyn, N. Y.

Chromium

Belmont Smelting & Refining Works, Inc., 322 Belmont Ave., Brooklyn, N. Y.
Carpenter Steel Co., Reading, Pa.
Electro Metallurgical Division, Union Carbide & Carbon Corp., 30 E. 42nd St., New York 17, N. Y.
Jarrell-Ash Co., 165 Neuberry St., Boston 16, Mass.
Mallory & Co., Inc., P. R., 3029 E. Washington St., Indianapolis 6, Ind.

Metals

Coefficient Metals

Carpenter Steel Co., Reading, Pa.
Gas & Oil Industry Laboratories, Inc., 2 Paine Ave., Irvington 11, N. J.
Mallory & Co., Inc., P. R., 3029 E. Washington St., Indianapolis 6, Ind.
Sherman & Co., 36–07 Prince St., Flushing, N. Y.
Stupakoff Ceramic & Mfg. Co., Latrobe, Pa.

Columbium

Jarrell-Ash Co., 165 Neuberry St., Boston 16, Mass.

Copper

Belmont Smelting & Refining Works, Inc., 322 Belmont Ave., Brooklyn, N. Y.
Federated Metals Div., American Smelting & Refining Co., 120 Broadway, New York 5, N. Y.
Imperial Bronze & Mfg. Co., Jellico, Tenn.
Jarrell-Ash Co., 165 Neuberry St., Boston 16, Mass.
Mallory & Co., Inc., P. R., 3029 E. Washington St., Indianapolis 6, Ind.
Revere Copper & Brass, Inc., 230 Park Ave., New York 17, N. Y.
U. S. Metals Refining Co., 61 Broadway, New York, N. Y.

Foil-Aluminum, Tin & Lead

Alpha Metals, Inc., 363 Hudson Ave., Brooklyn 1, N. Y.
Aluminum Co. of America, 2156 Gulf Bldg., Pittsburgh, Pa.
Bar-Ray Products, Inc., 209 25th St., Brooklyn 32, N. Y.
Belmont Smelting & Refining Works, Inc., 322 Belmont Ave., Brooklyn, N. Y.
Federated Metals Div., American Smelting & Refining Co., 120 Broadway, New York 5, N. Y.
Interelectronics Corp., 2432 Grand Concourse, New York 57, N. Y.
Jarrell-Ash Co., 165 Neuberry St., Boston 16, Mass.
Kaiser Aluminum & Chemical Sales, Inc., 1924 Broadway, Oakland 12, Calif.
National Lead Co., 111 Broadway, New York 6, N. Y.

Gallium

Eagle-Picher Co., Cincinnati, Ohio

Germanium

Eagle-Picher Co., Cincinnati, Ohio

Gold and Gold Alloys

American Platinum Works, N. J. R. R. Ave. at Oliver St., Newark 5, N. J.
American Silver Co., Inc., 36–07 Prince St., Flushing, N. Y.
Handy & Harman, 80–84 Fulton St., New York 7, N. Y.
Hoover & Strong, Inc., 129 W. Tupper Bldg., Buffalo, N. Y.
Jarrell-Ash Co., 165 Neuberry St., Boston 16, Mass.
Linick Chemical Co., 29 E. Madison St., Chicago 2, Ill.
Mallory & Co., Inc., P. R., 3029 E. Washington St., Indianapolis 6, Ind.
Ney Co., J. M., 7 Elm St., Hartford, Conn.
Pratt, Jr., C. L., 35 W. Grand River, Detroit 26, Mich.
Sherman & Co., 36–07 Prince St., Flushing, N. Y.
Western Gold & Platinum Works, 589 Bryant St., San Francisco, Calif.
Williams Gold Refining Co., Inc., 2978 Main St., Buffalo, N. Y.

High Permeability Alloys

Arnold Engineering Co., Marengo, Ill.
Carpenter Steel Co., Reading, Pa.

Metals

Mallory & Co., Inc., P. R., 3029 E. Washington St., Indianapolis 6, Ind.
Mullard Overseas Ltd., Century House, Shaftesbury Ave., London, W. C. 2.

Laminated Metal Parts

Alpha Metals, Inc., 363 Hudson Ave., Brooklyn 1, N. Y.
American Silver Co., Inc., 36–07 Prince St., Flushing, N. Y.
Andel & Co., Inc., 5218 N. Kedzie Ave., Chicago, Ill.
Sherman & Co., 36–07 Prince St., Flushing, N. Y.

Lead and Lead Alloys

Bar-Ray Products, Inc., 209 25th St., Brooklyn, N. Y.
Belmont Smelting & Refining Works, Inc., 322 Belmont Ave., Brooklyn, N. Y.
du Pont de Nemours & Co., E. I., Wilmington 98, Del.
Eagle-Picher Co., Cincinnati, Ohio
Federated Metals Div., American Smelting & Refining Co., 120 Broadway, New York 5, N. Y.
Imperial Bronze & Mfg. Co., Jellico, Tenn.
Jarrell-Ash Co., 165 Neuberry St., Boston 16, Mass.
Miller, Inc., Ray, 340 Dayton St., Newark, N. J.
National Lead Co., 111 Broadway, New York 6, N. Y.
Nuclear Instrument & Chemical Corp., 223 W. Erie St., Chicago 10, Ill. ADV. PG. Back Cover.
Technical Associates, Inc., 3730 San Fernando Rd., Glendale 4, Calif. ADV. PG. 94.

Magnesium

Belmont Smelting & Refining Works, Inc., 322 Belmont Ave., Brooklyn, N. Y.
Burgess Battery Co., Battery Div., Freeport, Ill.
Federated Metals Div., American Smelting & Refining Co., 120 Broadway, New York 5, N. Y.
Jarrell-Ash Co., 165 Neuberry St., Boston 16, Mass.

Manganese

Belmont Smelting & Refining Works, Inc., 322 Belmont Ave., Brooklyn, N. Y.
Electro Metallurgical Division, Union Carbide & Carbon Corp., 30 E. 42nd St., New York 17, N. Y.
Jarrell-Ash Co., 165 Neuberry St., Boston 16, Mass.

Mercury

Belmont Smelting & Refining Works, Inc., 322 Belmont Ave., Brooklyn, N. Y.
Hoover & Strong, Inc., 129 W. Tupper Bldg., Buffalo, N. Y.
Jarrell-Ash Co., 165 Neuberry St., Boston 16, Mass.
Jasonals Chemical Corp., 1085 Myrtle Ave., Brooklyn 6, N. Y.
Pratt, Jr., C. L., 35 W. Grand River, Detroit 26, Mich.
Williams Gold Refining Co., Inc., 2978 Main St., Buffalo, N. Y.

Molybdenum

Belmont Smelting & Refining Works, Inc., 322 Belmont Ave., Brooklyn, N. Y.
Cross Co., H., 15 Beekman St., New York 7, N. Y.
Jarrell-Ash Co., 165 Neuberry St., Boston 16, Mass.
Mallory & Co., Inc., P. R., 3029 E. Washington St., Indianapolis 6, Ind.
North American Philips Co., Inc., 100 E. 42nd St., New York 17, N. Y.
Sylvania Electric Products, Inc., 1740 Broadway, New York 19, N. Y.

Monel

Belmont Smelting & Refining Works, Inc., 322 Belmont Ave., Brooklyn, N. Y.
International Nickel Co., Inc., 67 Wall St., New York 5, N. Y.

Mallory & Co., Inc., P. R., 3029 E. Washington St., Indianapolis 6, Ind.
Miller, Inc., Ray, 340 Dayton St., Newark, N. J.
Pacific Foundry Co., Ltd., 3100 19th St., San Francisco, Calif.

Nickel and Nickel Alloys

American Oxygen Service Corp., 600 Essex St., Harrison, N. J.
American Silver Co., Inc., 36–07 Prince St., Flushing, N. Y.
Belmont Smelting & Refining Works, Inc., 322 Belmont Ave., Brooklyn, N. Y.
Carpenter Steel Co., Reading, Pa.
Federated Metals Div., American Smelting & Refining Co., 120 Broadway, New York 5, N. Y.
Gas & Oil Industry Laboratories, Inc., 2 Paine Ave., Irvington 11, N. J.
Haynes Stellite Division, Union Carbide & Carbon Corp., Kokomo, Indiana
International Nickel Co., Inc., 67 Wall St., New York 5, N. Y.
Jarrell-Ash Co., 165 Neuberry St., Boston 16, Mass.
Mallory & Co., Inc., P. R., 3029 E. Washington St., Indianapolis 6, Ind.
Miller, Inc., Ray, 340 Dayton St., Newark, N. J.
Pacific Foundry Co., Ltd., 3100 19th St., San Francisco, Calif.
Revere Copper & Brass, Inc., 230 Park Ave., New York 17, N. Y.
Sherman & Co., 36–07 Prince St., Flushing, N. Y.
Thomsen & Sons, L. C., Kenosha, Wis.

Nickel Ribbon

Carpenter Steel Co., Reading, Pa.
Jarrell-Ash Co., 165 Neuberry St., Boston 16, Mass.
Linick Chemical Co., 29 E. Madison St., Chicago 2, Ill.

Palladium

American Platinum Works, N. J. R. R. Ave. at Oliver St., Newark 5, N. J.
Handy & Harman, 80–84 Fulton St., New York 7, N. Y.
Hoover & Strong, Inc., 129 W. Tupper Bldg., Buffalo, N. Y.
Jarrell-Ash Co., 165 Neuberry St., Boston 16, Mass.
Linick Chemical Co., 29 E. Madison St., Chicago 2, Ill.
Mallory & Co., Inc., P. R., 3029 E. Washington St., Indianapolis 6, Ind.
Ney Co., J. M., 7 Elm St., Hartford, Conn.
Pratt, Jr., C. L., 35 W. Grand River, Detroit 26, Mich.
Sherman & Co., 36–07 Prince St., Flushing, N. Y.
Western Gold & Platinum Works, 589 Bryant St., San Francisco, Calif.
Western Gold Refining Co., Inc., 2978 Main St., Buffalo, N. Y.

Phospher Bronze

American Oxygen Service Corp., 600 Essex St., Harrison, N. J.
Belmont Smelting & Refining Works, Inc., 322 Belmont Ave., Brooklyn, N. Y.
Federated Metals Div., American Smelting & Refining Co., 120 Broadway, New York 5, N. Y.
Revere Copper & Brass, Inc., 230 Park Ave., New York 17, N. Y.

Platinum

American Platinum Works, N. J. R. R. Ave. at Oliver St., Newark 5, N. J.
Handy & Harman, 80–84 Fulton St., New York 7, N. Y.
Hoover & Strong, Inc., 129 W. Tupper Bldg., Buffalo, N. Y.

Metals

Jarrell-Ash Co., 165 Neuberry St., Boston 16, Mass.
Linick Chemical Co., 29 E. Madison St., Chicago 2, Ill.
Mallory & Co., Inc., P. R., 3029 E. Washington St., Indianapolis 6, Ind.
Ney Co., J. M., 7 Elm St., Hartford, Conn.
Pratt, Jr., C. L., 35 W. Grand River, Detroit 26, Mich.
Sherman & Co., 36–07 Prince St., Flushing, N. Y.
U. S. Metals Refining Co., 61 Broadway, New York, N. Y.
Western Gold & Platinum Works, 589 Bryant St., San Francisco, Calif.
Western Gold Refining Co., Inc., 2978 Main St., Buffalo, N. Y.

Polonium

Canadian Radium & Uranium Corp., 630 Fifth Ave., New York 20, N. Y. ADV. PG. 94.
Jarrell-Ash Co., 165 Neuberry St., Boston 16, Mass.
U. S. Radium Corp., 535 Pearl St., New York 7, N. Y.

Powdered

Antara Products, General Aniline & Film Corp., 444 Madison Ave., New York 17, N. Y.
Belmont Smelting & Refining Works, Inc., 322 Belmont Ave., Brooklyn, N. Y.
du Pont de Nemours & Co., E. I., Wilmington 98, Del.
Handy & Harman, 80–84 Fulton St., New York 7, N. Y.
Jarrell-Ash Co., 165 Neuberry St., Boston 16, Mass.
Linick Chemical Co., 29 E. Madison St., Chicago 2, Ill.
U. S. Metals Refining Co., 61 Broadway, New York, N. Y.
Western Gold & Platinum Works, 589 Bryant St., San Francisco, Calif.

Radium

Canadian Radium & Uranium Corp., 630 Fifth Ave., New York 20, N. Y. ADV. PG. 94.
Mallory & Co., Inc., P. R., 3029 E. Washington St., Indianapolis 6, Ind.
U. S. Radium Corp., 535 Pearl St., New York 7, N. Y.

Silicon

Belmont Smelting & Refining Works, Inc., 322 Belmont Ave., Brooklyn, N. Y.
Electro Metallurgical Division, Union Carbide & Carbon Corp., 30 E. 42nd St., New York 17, N. Y.
Jarrell-Ash Co., 165 Neuberry St., Boston 16, Mass.

Silver

American Platinum Works, N. J. R. R. Ave. at Oliver St., Newark 5, N. J.
American Silver Co., Inc., 36–07 Prince St., Flushing, N. Y.
Belmont Smelting & Refining Works, Inc., 322 Belmont Ave., Brooklyn, N. Y.
Handy & Harman, 80–84 Fulton St., New York 7, N. Y.
Hoover & Strong, Inc., 129 W. Tupper Bldg., Buffalo, N. Y.
Jarrell-Ash Co., 165 Neuberry St., Boston 16, Mass.
Linick Chemical Co., 29 E. Madison St., Chicago 2, Ill.
Mallory & Co., Inc., P. R., 3029 E. Washington St., Indianapolis 6, Ind.
Ney Co., J. M., 7 Elm St., Hartford, Conn.
Pratt, Jr., C. L., 35 W. Grand River, Detroit 26, Mich.
Sherman & Co., 36–07 Prince St., Flushing, N. Y.
U. S. Metals Refining Co., 61 Broadway, New York, N. Y.
Western Gold & Platinum Works, 589 Bryant St., San Francisco, Calif.

Metals

Silver Alloys and Compounds

American Oxygen Service Corp., 600 Essex St., Harrison, N. J.
American Platinum Works, N. J. R. R. Ave. at Oliver St., Newark 5, N. J.
American Silver Co., Inc., 36–07 Prince St., Flushing, N. Y.
Belmont Smelting & Refining Works, Inc., 322 Belmont Ave., Brooklyn, N. Y.
Handy & Harman, 80–84 Fulton St., New York 7, N. Y.
Hoover & Strong, Inc., 129 W. Tupper Bldg., Buffalo, N. Y.
Jarrell-Ash Co., 165 Neuberry St., Boston 16, Mass.
Linick Chemical Co., 29 E. Madison St., Chicago 2, Ill.
Mallory & Co., Inc., P. R., 3029 E. Washington St., Indianapolis 6, Ind.
Ney Co., J. M., 7 Elm St., Hartford, Conn.
Revere Copper & Brass, Inc., 230 Park Ave., New York 17, N. Y.
Sherman & Co., 36–07 Prince St., Flushing, N. Y.
Western Gold & Platinum Works, 589 Bryant St., San Francisco, Calif.
Western Gold Refining Co., Inc., 2978 Main St., Buffalo, N. Y.

Steel

Bethlehem Steel Co., Bethlehem, Pa.
Carpenter Steel Co., Reading, Pa.
Crucible Steel Co. of America, 405 Lexington Ave., New York 17, N. Y.
Houston Blow Pipe & Sheet Metal Works, P. O. Box 1692, Houston 1, Texas
Modern Welding Co., Owensboro, Ky.
Revere Copper & Brass, Inc., 230 Park Ave., New York 17, N. Y.

Steel, Stainless

American Oxygen Service Corp., 600 Essex St., Harrison, N. J.
Carpenter Steel Co., Reading, Pa.
Crucible Steel Co. of America, 405 Lexington Ave., New York 17, N. Y.
Houston Blow Pipe & Sheet Metal Works, P. O. Box 1692, Houston 1, Texas
Miller, Inc., Ray, 340 Dayton St., Newark , N. J.
Pacific Foundry Co., Ltd., 3100 19th St., San Francisco, Calif.
Pressed & Welded Steel Products Co., Inc., 38–57 11th St., Long Island City, N. Y.
Western Gold Refining Co., Inc., 2978 Main St., Buffalo, N. Y.

Strontium

Jarrell-Ash Co., 165 Neuberry St., Boston 16, Mass.

Tantalum

Belmont Smelting & Refining Works, Inc., 322 Belmont Ave., Brooklyn, N. Y.
Cross Co., H., 15 Beekman St., New York 7, N. Y.
Electro Metallurgical Division, Union Carbide & Carbon Corp., 30 E. 42nd St., New York 17, N. Y.
Jarrell-Ash Co., 165 Neuberry St., Boston 16, Mass.

Thermostatic Bi-Metals

Gas & Oil Industry Laboratories, Inc., 2 Paine Ave., Irvington 11, N. J.
Sherman & Co., 36–07 Prince St., Flushing, N. Y.

Tin

Alpha Metals, Inc., 363 Hudson Ave., Brooklyn 1, N. Y.
Andel & Co., Inc., 5218 N. Kedzie Ave., Chicago, Ill.
Belmont Smelting & Refining Works, Inc., 322 Belmont Ave., Brooklyn, N. Y.

Meters

Federated Metals Div., American Smelting & Refining Co., 120 Broadway, New York 5, N. Y.
Imperial Bronze & Mfg. Co., Jellico, Tenn.
Jarrell-Ash Co., 165 Neuberry St., Boston 16, Mass.
National Lead Co., 111 Broadway, New York 6, N. Y.

Titanium

Electro Metallurgical Division, Union Carbide & Carbon Corp., 30 E. 42nd St., New York 17, N. Y.
Mallory & Co., Inc., P. R., 3029 E. Washington St., Indianapolis 6, Ind.

Tungsten

American Oxygen Service Corp., 600 Essex St., Harrison, N. J.
Belmont Smelting & Refining Works, Inc., 322 Belmont Ave., Brooklyn, N. Y.
Electro Metallurgical Division, Union Carbide & Carbon Corp., 30 E. 42nd St., New York 17, N. Y.
Jarrell-Ash Co., 165 Neuberry St., Boston 16, Mass.
Mallory & Co., Inc., P. R., 3029 E. Washington St., Indianapolis 6, Ind.
North American Philips Co., Inc., 100 E. 42nd St., New York 17, N. Y.
Sylvania Electric Products, Inc., 1740 Broadway, New York 19, N. Y.

Tungsten Ribbon

Cross Co., H., 15 Beekman St., New York 7, N. Y.
Mallory & Co., Inc., P. R., 3029 E. Washington St., Indianapolis 6, Ind.
Sylvania Electric Products, Inc., 1740 Broadway, New York 19, N. Y.

Uranium

Jarrell-Ash Co., 165 Neuberry St., Boston 16, Mass.
Mallinkrodt Chemical Works, Second & Mallinkrodt Sts., St. Louis 7, Mo.

Zinc

Andel & Co., Inc., 5218 N. Kedzie Ave., Chicago, Ill.
Belmont Smelting & Refining Works, Inc., 322 Belmont Ave., Brooklyn, N. Y.
du Pont de Nemours & Co., Inc., E. I., Wilmington 98, Del.
Eagle-Picher Co., Cincinnati, Ohio
Federated Metals Div., American Smelting & Refining Co., 120 Broadway, New York 5, N. Y.
Jarrell-Ash Co., 165 Neuberry St., Boston 16, Mass.
National Lead Co., 111 Broadway, New York 6, N. Y.

Zirconium

Belmont Smelting & Refining Works, Inc., 322 Belmont Ave., Brooklyn, N. Y.
Electro Metallurgical Division, Union Carbide & Carbon Corp., 30 E. 42nd St., New York 17, N. Y.
Jarrell-Ash Co., 165 Neuberry St., Boston 16, Mass.
Mallory & Co., Inc., P. R., 3029 E. Washington St., Indianapolis 6, Ind.
Western Gold & Platinum Works, 589 Bryant St., San Francisco, Calif.

METERS—Counting Rate

Airlectron, Inc., P. O. Box 151, Caldwell, N. J.
Anton Electronic Labs., Inc., 1226–38 Flushing Ave., Brooklyn 6, N. Y. ADV. PG. 89.
Atomic Instrument Co., 84 Massachusetts Ave., Cambridge 39, Mass. ADV. PG. 101.
Austin Co., Special Devices Div., 19 Rector St., New York 6, N. Y.
Berkeley Scientific Co., 6th & Nevin Ave., Richmond, Calif.
Carnine & Bitter, 2332 Ontario Rd. NW, Washington 9, D. C.

Meters

Chatham Electronics Corp., 475 Washington St., Newark 2, N. J.
Cinema-Television Ltd., Worsley Bridge Rd., London, S. E. 26
Cyclotron Specialties Co., Moraga 8, Calif.
Douglas Radio Labs., 176 Norfolk Ave., Boston 19, Mass.
Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.
Electronics Associates, Inc., Long Branch, N. J.
Electronic Products Co., 111 E. 3rd St., Mt. Vernon, N. Y.
El-Tronics, Inc., 2649 N. Howard St., Philadelphia 33, Pa. ADV. PG. 76, 77.
Engineering Laboratories, Inc., 620 E. Fourth St., Tulsa 3, Okla.
Flader, Inc., Fredric, North Tonawanda, N. Y.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
General Radio Co., 275 Massachusetts Ave., Cambridge 30, Mass.
International Instruments, Inc., 331 East St., New Haven 11, Conn.
Kelley-Koett Instrument Co., 936 York St., Cincinnati 14, Ohio. ADV. PG. Inside Back Cover.
Leland Instruments, Ltd., 22–23 Millbank, London, S. W. 1.
Macdonald Co., Inc., W. S., 33 University Rd., Cambridge 38, Mass.
Mullard Overseas Ltd., Century House, Shaftesbury Ave., London, W. C. 2
Nuclear Instrument & Chemical Co., 223 W. Erie St., Chicago 10, Ill. ADV. PG. Back Cover.
Nuclear Measurements Corp., 3339 Central Ave., Indianapolis, Ind. ADV. PG. 96, 97.
Nucleonic Corp. of America, 497 Union St., Brooklyn 31, N. Y.
Potter Instrument Co., 115 Cutter Mill Rd., Great Neck, N. Y.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Radioactive Products, Inc., 3201 E. Woodbridge St., Detroit 7, Mich.
Special Instruments Laboratory, Inc., 1003 Highland Ave., Knoxville, Tenn. ADV. PG. 91.
Technical Associates, Inc., 3730 San Fernando Rd., Glendale 4, Calif. ADV. PG. 94.
Tracerlab, Inc., 130 High St., Boston 10, Mass. ADV. PG. 74, 75.
Western Radiation Labs., 1107 W. 24th St., Los Angeles 27, Calif.

METERS—Flow

American Oxygen Service Corp., 600 Essex St., Harrison, N. J.
Bailey Meter Co., 1044 Ivanhoe Rd., Cleveland 10, Ohio
Carnine & Bitter, 2332 Ontario Rd. NW, Washington 9, D. C.
Conoflow Corp., 2100 Arch St., Philadelphia 3, Pa.
Consolidated Siphon Supply Co., 24 Wooster St., New York, N. Y.
Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.
Fielden Instrument Corp., 2920 N. 4th St., Philadelphia 33, Pa.
Fischer & Porter Co., 50 County Line Rd., Hatboro, Pa.
Foxboro Co., 86 Neponset Ave., Foxboro, Mass.
Hastings Instrument Co., Box 1275, Hampton, Va.
Infilco, Inc., P. O. Box 5033, Tucson, Ariz.
Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne & Roberts Aves., Philadelphia 44, Pa. ADV. PG. 88.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Schutte & Koerting Co., 1254 N. 12th St., Philadelphia, Pa.

Meters

Scientific Glass Apparatus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.
Taylor Instrument Co., 95 Ames St., Rochester, N. Y.

METERS—Thermocouple

Baldwin Instrument Co., Ltd., Brooklands Works, Dartford, Kent
Carnine & Bitter, 2332 Ontario Rd. NW, Washington 9, D. C.
Farrand Optical Co., Inc., Bronx Blvd. at 238th St., New York 70, N. Y.
Foxboro Co., 86 Neponset Ave., Foxboro, Mass.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Hastings Instrument Co., Box 1275, Hampton, Va.
Industrial Controls, Inc., 525 N. Noble St., Chicago 22, Ill.
Leeds & Northrup Co., 4970 Stenton Ave., Philadelphia 44, Pa.
Lewis Engineering Co., 52 Rubber Ave., Naugatuck, Conn.
Marion Electrical Instrument Co., Manchester, N. H. ADV. PG. 98.
Meters, Inc., 915 Westfield Blvd., Indianapolis 20, Ind.
Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne & Roberts Aves., Philadelphia 44, Pa. ADV. PG. 88.
Pyrometer Instrument Co., Inc., Bergenfield, N. J.
Rawson Electrical Instrument Co., 114 Potter St., Cambridge 42, Mass.
Richards Co., Inc., Arklay S., 12 Winchester St., Newton Highlands 61, Mass.
Sensitive Research Instrument Corp., 9 Elm Ave., Mt. Vernon, N. Y.
Simpson Electric Co., Div. of American Gage & Machine Co., 5208 W. Kinzie St., Chicago 44, Ill. ADV. PG. 107.
Tagliabue Instruments Div. of Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.
Thwing-Albert Instrument Co., 5351 Pulaski Ave., Philadelphia 44, Pa.
Triplett Electrical Instrument Co., 286 Harmon Rd., Bluffton, Ohio.
Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.
Wheelco Instruments Co., 847 W. Harrison St., Chicago 7, Ill.

METERS—X-Ray Intensity

Anton Electronic Labs., Inc., 1226–38 Flushing Ave., Brooklyn 6, N. Y. ADV. PG. 89.
Baldwin Instrument Co., Ltd., Brooklands Works, Dartford, Kent
Chatham Electronics Corp., 475 Washington St., Newark 2, N. J.
El-Tronics, Inc, 2649 N. Howard St., Philadelphia 33, Pa. ADV. PG. 76, 77.
Fleming Radio (Developments) Ltd., 18–20 Laystall St., London, E. C. 1.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
General Electric X-Ray Corp., 4855 Electric Ave., Milwaukee, Wis. ADV. PG. 73.
Kelley-Koett Instrument Co., 936 York St., Cincinnati 14, Ohio. ADV. PG. Inside Back Cover.
Leeds & Northrup Co., 4970 Stenton Ave., Philadelphia 44, Pa.
Marconi Instruments, Ltd., 23–25 Beaver St., New York 4, N. Y.
Nuclear Instrument & Chemical Corp., 223 W. Erie St., Chicago 10, Ill. ADV. PG. Back Cover.
Nucleonic Corp. of America, 497 Union St., Brooklyn 31, N. Y.
Picker X-Ray Corp., 300 Fourth Ave., New York 10, N. Y.

Micro-Ammeters

Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Radioactive Products, Inc., 3201 E. Woodbridge St., Detroit 7, Mich.
Special Instruments Laboratory, Inc., 1003 Highland Ave., Knoxville, Tenn. ADV. PG. 91.
Technical Associates, Inc., 3730 San Fernando Rd., Glendale 4, Calif. ADV. PG. 94.
Tracerlab, Inc., 130 High St., Boston 10, Mass. ADV. PG. 74, 75.
Victoreen Instrument Co., 3800 Perkins Ave., Cleveland, Ohio. ADV. PG. Inside Front Cover.

MICRO-AMMETERS—Electronic

Beta Electric Corp., 333 E. 103rd St., New York 29, N. Y.
Millivac Instruments, Box 3027, New Haven, Conn.
Radio Corp. of America, RCA Victor Div. Engineering Products Dept., Front & Cooper Sts., Camden, N. J. ADV. PG. 95.

MICROCHEMICAL EQUIPMENT

Brandt, William A., Box 188, Kutztown, Pa.
Eimer & Amend, 635 Greenwich St., New York, N. Y.
Ferner Co., R. Y., 110 Pleasant St., Malden, Mass.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Scientific Glass Apparatus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.

MICROSCOPES

American Optical Co., Southbridge, Mass.
Bausch & Lomb Optical Co., 635 St. Paul St., Rochester 2, N. Y.
Buhl Optical Co., 1009 Beech Ave., Pittsburgh 12, Pa.
Clarkstan Corp., 11921 SW Pico Blvd., Los Angeles 64, Calif.
Farrand Optical Co., Inc., Bronx Blvd. at 238th St., New York 70, N. Y.
Ferner Co., R. Y., 110 Pleasant St., Malden, Mass.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Gaertner Scientific Corp., 1237 Wrightwood Ave., Chicago, Ill.
Jarrell-Ash Co., 165 Newberry St., Boston 16, Mass.
Leitz, Inc., E., 304 Hudson St., New York 13, N. Y. ADV. PG. 93.
Mine Safety Appliances Co., Braddock, Thomas & Meade Sts., Pittsburgh 8, Pa.
Scientific Glass Apparatus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.

MICROSCOPES—Electron

Farrand Optical Co., Inc., Bronx Blvd. & 238th St., New York 70, N. Y.
North American Philips Co., Inc., 100 E. 42nd St., New York 17, N. Y.
Radio Corp. of America, RCA Victor Div., Engineering Products Dept., Front & Cooper Sts., Camden, N. J. ADV. PG. 95.

MILLS—Laboratory

Allis-Chalmers Mfg. Co., 864 S. 70th St., Milwaukee 1, Wis.
Beach-Russ Co., 44 Church St., New York 7, N. Y.
Central Scientific Co., 1700 Irving Park Rd., Chicago 13, Ill.
Colloid Equipment Co., Inc., 48 Church St., New York, N. Y.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Industrial Products Engineering Co., 44–26 Hunter St., Long Island City, N. Y.
International Engineering, Inc., 1200 Bolander Ave., Dayton, Ohio
Laboratory Construction Co., 1115 Holmes St., Kansas City, Mo.

Monitors

Scientific Glass Apparatus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.

MIXERS—Laboratory

Beach-Russ Co., 44 Church St., New York 7, N. Y.
Brookfield Engineering Labs., Inc., Porter St., Stoughton, Mass.
Central Scientific Co., 1700 Irving Park Rd., Chicago 13, Ill.
Colloid Equipment Co., Inc., 48 Church St., New York, N. Y.
Consolidated Siphon Supply Co., 24 Wooster St., New York, N. Y.
Eberbach & Son Co., Inc., Ann Arbor, Mich.
Eimer & Amend, 635 Greenwich St., New York, N. Y.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
General Mixing Equipment Co., 411 N. 3rd St., Philadelphia, Pa.
Industrial Products Engineering Co., 44–26 Hunter St., Long Island City, N. Y.
International Engineering, Inc., 1200 Bolander Ave., Dayton, Ohio
Mixing Equipment Co., 192 Mt. Read Blvd., Rochester 11, N. Y.
Precision Scientific Co., 3737 Cortland Ave., Chicago, Ill.
Scientific Glass Apparatus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.
United Blower Co., Inc., 193 Center St., New York, N. Y.

MONITORS—Area

Atomic Instrument Co., 84 Massachusetts Ave., Cambridge 39, Mass. ADV. PG. 101.
Austin Co., Special Devices Div., 19 Rector St., New York 6, N. Y.
Beckman Instruments, Inc., 820 Mission St., South Pasadena, Calif. ADV. PG. 85.
Electronic Products Co., 111 E. 3rd St., Mt. Vernon, N. Y.
El-Tronics, Inc., 2649 N. Howard St., Philadelphia 33, Pa. ADV. PG. 76, 77.
Fleming Radio (Developments) Ltd., 1820 Laystall St., London, E. C. 1.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
Kelley-Koett Instrument Co., 936 York St., Cincinnati 14, Ohio. ADV. PG. Inside Back Cover.
Menlo Research Laboratory, Menlo Park, Calif.
Mullard Overseas Ltd., Century House, Shaftesbury Ave., London, W. C. 2.
National Intercommunicating Systems, 1531 Devon Ave., Chicago 26, Ill.
Nuclear Instrument & Chemical Corp., 223 W. Erie St., Chicago 10, Ill. ADV. PG. Back Cover.
Nuclear Measurements Corp., 3339 Central Ave., Indianapolis, Ind. ADV. PG. 96, 97.
Nucleonic Corp. of America, 497 Union St., Brooklyn 31, N. Y.
R-C Scientific Instrument Co., 335 Culver Blvd., Playa Del Ray, Calif.
Radiaphone Co., 2435 E. Colorado St., Pasadena, Calif.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Technical Associates, Inc., 3730 San Fernando Rd., Glendale 4, Calif. ADV. PG. 94.
Telemark, Inc., 79 Prospect St., Stamford, Conn.
Tracerlab, Inc., 130 High St., Boston 10, Mass. ADV. PG. 74, 75.
Wayne-Kerr Laboratories, Ltd., New Malden, Surrey, England

MONITORS—Personnel

Atomic Instrument Co., 84 Massachusetts Ave., Cambridge 39, Mass. ADV. PG. 101.

Monitors

Austin Co., Special Devices Div., 19 Rector St., New York 6, N. Y.
Baldwin Instrument Co., Ltd., Brooklands Works, Dartford, Kent.
Beckman, Inc., Arnold O., 1020 Mission St., South Pasadena, Calif.
Beckman Instruments, Inc., 820 Mission St., South Pasadena, Calif. ADV. PG. 85.
Berkeley Scientific Co., 6th & Nevin Ave., Richmond, Calif.
Cambridge Instrument Co., Inc., 3786 Grand Central Terminal, New York 17, N. Y.
Douglas Radio Labs., 176 Norfolk Ave., Boston 19, Mass.
Electronic Products Co., 111 E. 3rd St., Mt. Vernon, N. Y.
El-Tronics, Inc., 2649 N. Howard St., Philadelphia 33, Pa. ADV. PG. 76, 77.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
Kelley-Koett Instrument Co., 936 York St., Cincinnati 14, Ohio. ADV. PG. Inside Back Cover.
Mullard Overseas Ltd., Century House, Shaftesbury Ave., London, W. C. 2.
National Intercommunicating Systems, 1531 Devon Ave., Chicago 26, Ill.
Nuclear Instrument & Chemical Corp., 223 W. Erie St., Chicago 10, Ill. ADV. PG. Back Cover.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Samples Machine Co., A. M., 506 N. Central Ave., Knoxville, Tenn.
Technical Associates, Inc., 3730 San Fernando Rd., Glendale 4, Calif. ADV. PG. 94.
Tracerlab, Inc., 130 High St., Boston 10, Mass. ADV. PG. 74, 75.
Wayne-Kerr Laboratories, Ltd., New Malden, Surrey, England
Western Radiation Labs., 1107 W. 24th St., Los Angeles 7, Calif.

MONITORS—Sample

Atomic Instrument Co., 84 Massachusetts Ave., Cambridge 39, Mass. ADV. PG. 101.
Douglas Radio Labs., 176 Norfolk Ave., Boston 19, Mass.
Electronic Products Co., 111 E. 3rd St., Mt. Vernon, N. Y.
El-Tronics, Inc., 2649 N. Howard St., Philadelphia 33, Pa. ADV. PG. 76, 77.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Kelley-Koett Instrument Co., 936 York St., Cincinnati 14, Ohio. ADV. PG. Inside Back Cover.
Nuclear Instrument & Chemical Corp., 223 W. Erie St., Chicago 10, Ill. ADV. PG. Back Cover.
Nuclear Measurements Corp., 3339 Central Ave., Indianapolis, Ind. ADV. PG. 96, 97.
Nucleonic Corp. of America, 497 Union St., Brooklyn 31, N. Y.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Special Instruments Laboratory, Inc., 1003 Highland Ave., Knoxville, Tenn. ADV. PG. 91.
Technical Associates, Inc., 3730 San Fernando Rd., Glendale 4, Calif. ADV. PG. 94.
Tracerlab, Inc., 130 High St., Boston 10, Mass. ADV. PG. 74, 75.

MOTORS—Fractional hp

Carron Mfg. Co., 741 W. Harrison St., Chicago 7, Ill.
Eastern Air Devices, Inc., 585 Dean St., Brooklyn 17, N. Y.
Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.

Oscillographs

Eicor, Inc., 1501 W. Congress St., Chicago 7, Ill.
Electric Indicator Co., 21 Parker Ave., Stamford, Conn.
Fairchild Camera & Instrument Corp., 88-06 Van Wyck Blvd., Jamaica 1, N. Y.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
Red Bank Division, Bendix Aviation Corp., Red Bank, N. J.
Russell Electric Co., 4501 South Western Blvd., Chicago 9, Ill.
Small Motors Inc., 2076 Elston Ave., Chicago 14, Ill.
Sperry Gyroscope Co., Div. of The Sperry Corp., Great Neck, N. Y.
U. S. Electrical Motors, Inc., 200 E. Slauson Ave., Los Angeles 64, Calif.
Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa.

NEUTRON SOURCES

Canadian Radium & Uranium Corp., 630 Fifth Ave., New York 20, N. Y. ADV. PG. 94.
Eldorado Mining & Refining Co., Ottawa, Canada
Radium Chemical Co., 570 Lexington Ave., New York, N. Y.
U. S. Radium Corp., 535 Pearl St., New York 7, N. Y.

OPTICAL INSTRUMENTS

Abrams Instrument Corp., 600–620 E. Schiawassee St., Lansing, Mich.
American Optical Co., Southbridge, Mass.
Arlington Electric Products, Inc., 500 W. 52nd St., New York 19, N. Y.
Austin Co., Special Devices Div., 19 Rector St., New York 6, N. Y.
Bausch & Lomb Optical Co., 635 St. Paul St., Rochester 2, N. Y.
Beckman & Whitley, Inc., 985 San Carlos Ave., San Carlos, Calif.
Buhl Optical Co., 1009 Beech Ave., Pittsburgh 12, Pa.
Clarkstan Corp., 11921 SW Pico Blvd., Los Angeles 64, Calif.
Farrand Optical Co., Inc., Bronx Blvd. at 238th St., New York 70, N. Y.
Ferner Co., R. Y., 110 Pleasant St., Malden, Mass.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Gaertner Scientific Corp., 1237 Wrightwood Ave., Chicago, Ill.
Hathaway Instrument Co., 1315 S. Clarkson St., Denver 10, Colo.
Heinicke Instrument Corp., 315 Alexander St., Rochester 4, N. Y.
Jarrell-Ash Co., 165 Neuberry St., Boston 16, Mass.
Leitz, Inc., E., 314 Hudson St., New York 13, N. Y. ADV. PG. 93.
Optical Film Engineering Co., 2125 Cherry St., Philadelphia 3, Pa.
Perkin-Elmer Corp., Norwalk, Conn.
Phoenix Precision Instrument Co., 3803 N. 5th St., Philadelphia, Pa.
Process & Instruments, 60 Greenpoint Ave., Brooklyn 22, N. Y.
Scientific Glass Apparatus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.

OSCILLOGRAPHS

Alden Products Co., 117 No. Main St., Brockton 64, Mass.
Brush Development Co., The, 3405 Perkins Ave., Cleveland 14, Ohio.
Century Geophysical Corp., P. O. Box 6216, Tulsa 10, Oklahoma
Consolidated Engineering Corp., 620 N. Lake Ave., Pasadena 4, Calif. ADV. PG. 82.

Oscilloscopes

Electronic Tube Corp., 1200 E. Mermaid Lane, Philadelphia 18, Pa.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
Hathaway Instrument Co., 1315 S. Clarkson St., Denver 10, Colo.
Heiland Research Corp., 130 E. 5th Ave., Denver 9, Colo.
Industrial Science Associates, 542 Fifth Ave., New York 19, N. Y.
Miller Corp., Wm., 362 W. Colorado St., Pasadena, Calif.
Mullard Overseas Ltd., Century House, Shaftesbury Ave., London, W. C. 2.
Rahm Instruments, Inc., 12 West Broadway, New York 7, N. Y.
Sanborn Co., 39 Osborn St., Cambridge 39, Mass.
Southwestern Industrial Electronic Co., 2831 Post Oak Rd., Houston 19, Texas.
Tech Laboratories, Inc., Bergen & Edsall Blvds., Palisades Park, N. J.
Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa.

OSCILLOSCOPES

Beta Electric Corp., 333 E. 103rd St., New York 29, N. Y.
Electronic Instrument Co., Inc., 276 Newport St., Brooklyn 12, N. Y.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
Industrial Electronics, Inc., 8060 Wheeler St., Detroit 10, Mich.
Plastics & Electronics Co., 272 Northland Ave., Buffalo 8, N. Y.

OSCILLOSCOPES—Cathode Ray

American Electroneering Co., 2112 S. LaBrea Ave., Los Angeles, Calif.
Beta Electric Corp., 333 E. 103rd St., New York 29, N. Y.
Cambridge Instrument Co., Inc., 3786 Grand Central Terminal, New York 17, N. Y.
Central Scientific Co., 1700 Irving Park Rd., Chicago 13, Ill.
Cinema-Television Ltd., Worsley Bridge Rd., London, S. E. 26
Cossor (Canada) Ltd., 301 Windsor St., Halifax, N. S., Canada
Du Mont Laboratories, Inc., Allen B., Instrument Div., 1000 Main Ave., Clifton, N. J.
Electronic Instrument Co., Inc., 276 Newport St., Brooklyn 12, N. Y.
Electronic Tube Corp., 1200 E. Mermaid Lane, Philadelphia 18, Pa.
Electronic Workshop, Inc., 351 Bleecker St., New York 14, N. Y.
Eltron, Inc., 407 N. Jackson St., Jackson, Mich.
El-Tronics, Inc., 2649 N. Howard St., Philadelphia 33, Pa. ADV. PG. 76, 77.
Fleming Radio (Developments) Ltd., 18–20 Laystall St., London, E. C. 1.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Furst Electronics, 20 S. Jefferson St., Chicago 6, Ill.
General Electric Co., Electronics Dept., Electronics Park, Syracuse, N. Y. ADV. PGS. 65 to 72.
Hathaway Instrument Co., 1315 S. Clarkson St., Denver 10, Colo.
Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland, Ohio.
Industrial Electronics, Inc., 8060 Wheeler St., Detroit 10, Mich.
Leland Instruments Ltd., 22–23 Millbank, London, S. W. 1
Marconi Instruments, Ltd., 23–25 Beaver St., New York 4, N. Y.

Paints

Millen Mfg. Co., James, 150 Exchange St., Malden, Mass.
Mullard Overseas Ltd., Century House, Shaftesbury Ave., London, W. C. 2
Plastics & Electronics Co., 272 Northland Ave., Buffalo 8, N. Y.
Radio Corp. of America, RCA Victor Div., Tube Dept., 415 S. Fifth St., Harrison, N. J. ADV. PG. 83, 87
Precision Apparatus Co., Inc., 92–27 Horace Harding Blvd., Elmhurst, N. Y.
Process & Instruments, 60 Greenpoint Ave., Brooklyn 22, N. Y.
Radioactive Products, Inc., 3201 E. Woodbridge St., Detroit 7, Mich.
Simpson Electric Co., Div. of American Gage & Machine Co., 5208 W. Kinzie St., Chicago 44, Ill. ADV. PG. 107.
Supreme, Inc., Greenwood, Miss.
Sylvania Electric Products, Inc., 1740 Broadway, New York 19, N. Y.
Tech Laboratories, Inc., Bergen & Edsall Blvds., Palisades Park, N. J.
Teletronics Laboratory, Inc., 352 Maple Ave., Westbury, N. Y.
Television Equipment Corp., 238 William St., New York, N. Y. ADV. PG. 79.
Triumph Mfg. Co., 913 W. Van Buren St., Chicago 7, Ill.
Waterman Products Co., Inc., 2445–63 Emerald St., Philadelphia 25, Pa.

OVENS—Laboratory

Belke Mfg. Co., 947 N. Cicero Ave., Chicago 51, Ill.
Bowser, Inc., Refrigeration Div., Terryville, Conn.
Colloid Equipment Co., Inc., 48 Church St., New York, N. Y.
Eclipse Fuel Engineering Co., 705 S. Main St., Rockford, Ill.
Eimer & Amend, 635 Greenwich St., New York, N. Y.
Electric Hotpack Co., Inc., 5035 Cottman Ave., Philadelphia, Pa.
Emerson-Sack-Warner Corp., 92 Beverly, Boston, Mass.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Grieve-Hendry Co., 1101 N. Paulina St., Chicago, Ill.
Hones, Inc., Charles A., 122 S. Grand Ave., Baldwin, N. Y.
Houston Blow Pipe & Sheet Metal Works, P. O. Box 1692, Houston 1, Texas
Humboldt Mfg. Co., 2016 N. Whipple, Chicago, Ill.
Precision Scientific Co., 3737 Cortland Ave., Chicago, Ill.
Rockwell Co., W. S., 200 Elliott St., Fairfield, Conn.
Scientific Glass Apparatus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.
Stromes Systems, Inc., 22nd St. & Sixth Ave., New York, N. Y.
Tenney Engineering, Inc., 26 Avenue B, Newark 5, N. J.

PAINTS—Protective

Arco Co., 7301 Bessemer Ave., Cleveland 27, Ohio
Atlas Mineral Products Co., 121 Norman St., Mertztown, Pa.
Canadian Radium & Uranium Corp., 630 Fifth Ave., New York 20, N. Y. ADV. PG. 94.
Ceilcote Co., Rockefeller Bldg., Cleveland, Ohio
Devoe & Raynolds Co., Inc., 787 First Ave., New York, N. Y.
duPont de Nemours & Co., Inc., E. I., Wilmington 98, Del.
Eagle-Picher Co., Cincinnati, Ohio
Electro Chemical Supply & Engineering Co., 750 Broad St., Emmans, Pa.

Panels & Wallboard

General Cement Mfg. Co., 919 Taylor Ave., Rockford, Ill.
Glidden Co., 11001 Madison Ave., Cleveland 2, Ohio
Gordon-Lacey Chemical Products Co., Inc., 57–02 48th St., Maspeth, N. Y.
Hague & Co., Alfred, 226 34th St., Brooklyn, N. Y.
Hollingshead Corp., R. M., Cocoan Engineering Div., 840 Cooper St., Camden, N. J.
Horn Co., Inc., A. C., 10th St. & 44th Ave., Long Island City 1, N. Y.
Inertol Co., Inc., 480 Frelinghuysen Ave., Newark 5, N. J.
Interelectronics Corps., 2432 Grand Concourse, New York 57, N. Y.
Knight, Maurice A., 171 Kelly Ave., Akron, Ohio
Lasting Products Co., 202 S. Franklintown Rd., Baltimore 23, Md.
Micro-Circuits Co., New Buffalo, Mich.
Monsanto Chemical Co., 1700 S. Second St., St. Louis 4, Mo.
Nucleonic Corp. of America, 497 Union St., Brooklyn 31, N. Y.
Nukem Products Corp., 111 Colgate Ave., Buffalo 20, N. Y.
Prufcoat Laboratories, Inc., 61 Main St., Cambridge, Mass.
Quigley Co., Inc., 527 Fifth Ave., New York, N. Y.
Reilly Tar & Chemical Corp., 1615 Merchants Bank Bldg., 11 S. Meridan St., Indianapolis, Ind.
Rulon Inc., Ralph V., Second & Pike Sts., Philadelphia, Pa.
Saran Protective Coatings Co., 2415 Burdette Ave., Ferndale 20, Mich.
Stonhard Co., 1306 Spring Garden St., Philadelphia 23, Pa.
Tufcrete Co., 554 Teachout Bldg., Des Moines 9, Iowa
United Chromium, Inc., 100 East 42nd St., New York, N. Y.
Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa.

PANELS & WALLBOARD—Pressed Wood

Aetna Plywood & Veneer Co., 1738 Elston Ave., Chicago, Ill.
Armstrong Cork Co., 1010 Concord St., Lancaster, Pa.
Glenwood Mfg. Co., 2606 N. San Fernando Blvd., Burbank, Calif.
Technical Ply-Woods, 226 N. LaSalle St., Chicago, Ill.
Woodall Industries, Inc., Laurel, Miss.

PHOSPHORS—Scintillation & Conduction

Linde Air Products Co., Unit of Union Carbide & Carbon Corp., 30 E. 42nd St., New York 17, N. Y.
Macdonald Co., Inc., W. S., 33 University Rd., Cambridge 38, Mass.
National Radiac, Inc., 475 Washington St., Newark 2, N. J.
Nuclear Research Corp., 112 S. 16th St., Philadelphia 2, Pa. ADV. PG. 109.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Standard Electronics Research Corp., 2 East End Ave., New York 21, N. Y.
Tracerlab, Inc., 130 High St., Boston 10, Mass. ADV. PG. 74, 75.
U. S. Radium Corp., 535 Pearl St., New York 7, N. Y.

Photometers

PHOTOGRAPHIC MATERIALS—Films and Papers for Recording Instruments

Alden Products Co., 117 N. Main St., Brockton 64, Mass.
Ansco Div. of General Aniline & Film Corp., Binghamton, N. Y.
du Pont de Nemours & Co., Inc., E. I., Wilmington 98, Delaware
Eastman Kodak Co., Rochester 4, N. Y.
Hathaway Instrument Co., 1315 S. Clarkson St., Denver 10, Colo.
Haloid Co., The, 6 Haloid St., Rochester, N. Y.
Heincke Instrument Corp., 315 Alexander St., Rochester 4, N. Y.
St. John X-Ray Laboratory, Califon, N. J.

PHOTOGRAPHIC MATERIALS—Spectrographic Instruments

Applied Research Labs., 4336 San Fernando Rd., Glendale 4, Calif.
Eastman Kodak Co., Rochester 4, N. Y.
Heinicke Instrument Corp., 315 Alexander St., Rochester 4, N. Y.
Jarrell-Ash Co., 165 Newberry St., Boston 16, Mass.
Marconi Instruments, Ltd., 23–25 Beaver St., New York 4, N. Y.

PHOTOGRAPHIC PLATE—Film & Nuclear

Eastman-Kodak Co., Rochester 4, N. Y.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Heinicke Instrument Corp., 315 Alexander St., Rochester 4, N. Y.
Ward's Natural Science, 3000 Ridgewood Rd. E., Rochester, N. Y.

PHOTOMETRIC EQUIPMENT

American Scientific Co., P. O. Box 1, Highbridge Station, New York 52, N. Y.
Baldwin Instrument Co., Ltd., Brooklands Works, Dartford, Kent
Davies Laboratories, Inc., 4705 Queensbury Rd., Riverdale, Md.
Electronic Workshop, Inc., 351 Bleecker St., New York 14, N. Y.
Farrand Optical Co., Inc., Bronx Blvd. at 238th St., New York 70, N. Y.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
Heinicke Instrument Corp., 315 Alexander St., Rochester 4, N. Y.
Jarrell-Ash Co., 165 Newberry St., Boston 16, Mass.
Leeds & Northrup Co., 4970 Stenton Ave., Philadelphia 44, Pa.
Menlo Research Laboratory, Menlo Park, Calif.
Minnesota Electronics Corps., 97 E. Fifth St., St. Paul 1, Minn.
Phoenix Precision Instrument Co., 3803 N. 5th St., Philadelphia, Pa.
Photobell Company, 116 Nassau St., New York 7, N. Y.
Photovolt Corp., 95 Madison Ave., New York 16, N. Y. ADV. PG. 104.
Process & Instruments, 60 Greenpoint Ave., Brooklyn 22, N. Y.
Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.

PHOTOMETERS—Light-Transmission

Baldwin Instrument Co., Ltd., Brooklands Works, Dartford, Kent.

Photomicrographic Equipment

Davies Laboratories, Inc., 4705 Queensbury Rd., Riverdale, Md.
Eimer & Amend, 635 Greenwich St., New York, N. Y.
Ess Instrument Co., 98 S. Washington St., Bergenfield, N. J.
Farrand Optical Co., Inc., Bronx Blvd. at 238th St., New York 70, N. Y.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
Heinicke Instrument Corp., 315 Alexander St., Rochester 4, N. Y.
Jarrell-Ash Co., Newberry St., Boston 16, Mass.
Leeds & Northrup Co., 4970 Stenton Ave., Philadelphia 44, Pa.
Minnesota Electronics Corp., 97 E. Fifth St., St. Paul 1, Minn.
Phoenix Precision Instrument Co., 3803 N. 5th St., Philadelphia, Pa.
Photobell Company, 116 Nassau St., New York 7, N. Y.
Photovolt Corp., 95 Madison Ave., New York 16, N. Y. ADV. PG. 104.
Scientific Glass Apparatus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.
Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.

PHOTOMICROGRAPHIC EQUIPMENT

American Optical Co., Southbridge, Mass.
Baldwin Instrument Co., Ltd., Brooklands Works, Dartford, Kent
Bausch & Lomb Optical Co., 635 St. Paul St., Rochester 2, N. Y.
Ferner Co., R. Y., 110 Pleasant St., Malden, Mass.
Frese Corp., Adolph, 116 W 17th St., Los Angeles, Calif.
Heinicke Instrument Corp., 315 Alexander St., Rochester 4, N. Y.
Photovolt Corp., 95 Madison Ave., New York 16, N. Y. ADV. PG. 104.

PIPE—Glass

Able Scientific Glass Apparatus Co., 6859 South Anthony Ave., Chicago 37, Ill. ADV. PG. 106.
Dallons Labs., 5066 Santa Monica Blvd., Los Angeles, Calif.
Fischer & Porter Co., 50 County Line Rd., Hatboro, Pa.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Miller, Inc., Ray, 340 Dayton St., Newark, N. J.
Scientific Glass Apparatus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.

PIPE—Hard Rubber

Day Co., 820 3rd Ave., NE, Minneapolis, Minn.
Goodrich Co., B. F., 448 S. Main St., Akron, Ohio
Luzerne Rubber Co., Dewey St., Trenton, N. J.
Miller, Inc., Ray, 340 Dayton St., Newark, N. J.
U. S. Rubber Co., Electroforming Dept., 6602 Jefferson Ave., Detroit, Mich.

PIPE—Metal

Aluminum Co. of America, 2156 Gulf Bldg., Pittsburgh, Pa.
Buttling-Padgett Co., Inc., 830 Whittier, New York, N. Y.
International Nickel Co., Inc., 67 Wall St., New York 5, N. Y.
Pacific Foundry Co., Ltd., 3100 19th St., San Francisco, Calif.

Plastics

PIPE—Stainless Steel

Astell & Co., Inc., John B., 90 West Broadway, New York 7, N. Y.
Carpenter Steel Co., Reading, Pa.
Consolidated Siphon Supply Co., 24 Wooster St., New York, N. Y.
Emerson-Sack-Warner Corp., 92 Beverly, Boston, Mass.
Globe Steel Tubes Co., Milwaukee, Wis.
Harris, Inc., Machine Works, 61 S. E. Yamhill, Portland, Ore.
Houston Blow Pipe & Sheet Metal Works, P. O. Box 1692, Houston, Texas
Metal Products Corp., 48 W. 19th St., Weehawken, N. J.
Miller, Inc., Ray, 340 Dayton St., Newark, N. J.
Oat & Sons, Inc., Joseph, Broad & Quarry Sts., Philadelphia, Pa.
Old Dominion Iron & Steel Corp., Bell Isle, Richmond, Va.
Pacific Foundry Co., Ltd., 3100 19th St., San Francisco, Calif.

PIPETTES—Automatic

Eimer & Amend, 635 Greenwich St., New York, N. Y.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Scientific Glass Apparatus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.
Special Glass Products Co., 2 W. 33rd St., New York, N. Y.

PLANCHETS

Douglas Radio Labs., 176 Norfolk Ave., Boston 19, Mass.
Nuclear Instrument & Chemical Corp., 223 W. Erie St., Chicago 10, Ill. ADV. PG. Back Cover.
Nuclear Measurements Corps., 3339 Central Ave., Indianapolis, Ind. ADV. PG. 96, 97.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Special Instruments Laboratory, Inc., 1003 Highland Ave., Knoxville, Tenn. ADV. PG. 91.
Technical Associates, Inc., 3730 San Fernando Rd., Glendale 4, Calif. ADV. PG. 94.
Tracerlab, Inc., 130 High St., Boston 10, Mass. ADV. PG. 74, 75.

PLASTICS—Laminated

Woodall Industries, Inc., Laurel, Miss.

PLASTICS—Protective

Aetna Plywood & Veneer Co., 1738 Elston Ave., Chicago, Ill.
Atlas Mineral Products Co., 121 Norman St., Mertztown, Pa.
Belke Mfg. Co., 947 N. Cicero Ave., Chicago 51, Ill.
Cooper Co., D. C., 1467 S. Michigan Ave., Chicago, Ill.
du Pont de Nemours & Co., Inc., E. I., Wilmington 98, Del.
Durez Plastics & Chemicals Inc., 1921 Walck Rd., North Tonawanda, N. Y.
Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.
Emerson & Cuming Co., 126 Massachusetts Ave., Boston 15, Mass.
General Electric Co., Chemical Dept., Pittsfield, Mass. ADV. PGS. 65 to 72.
General Electric Co., Electronics Dept., Electronics Park, Syracuse, N. Y. ADV. PGS. 65 to 72.

Plates

Gordon-Lacey Chemical Products Co., Inc., 57–02 48th St., Maspeth, N. Y.
Hochmeister-Inc., 2332 Forbes St., Pittsburgh 13, Pa.
Hollingshead Corp., R. M., Cocoon Engineering Div., 840 Cooper St., Camden, N. J.
Keystone Electronics Corp., 423 Broome St., New York 12, N. Y.
Lasting Products Co., 202 S. Franklintown Rd., Baltimore 23, Md.
Monsanto Chemical Co., 1700 S. Second St., St. Louis 4, Mo.
Penn Fibre & Specialty Co., 2020 E. Westmoreland St., Philadelphia 34, Pa.
United Chromium, Inc., 100 East 42nd St., New York, N. Y.
U. S. Gasket Co., 602 N. 10th St., Camden, N. J.
Willson Products, Inc., Reading, Pa.

PLATES—Hot

Acme Electric Heating Co., Inc., 1205 Washington St., Boston, Mass.

PLYWOOD—Metal-Clad

Andel & Co., Inc., 5218 N. Kedzie Ave., Chicago, Ill.
Keller Products, Inc., Manchester, N. H.
U. S. Plywood Corp., 55 W. 42nd St., New York, N. Y.

POTENTIOMETERS

Allen-Bradley Co., 136 W. Greenfield Ave., Milwaukee 4, Wis.
Brown Electro-Measurement Corp., 4637 SE. Hawthorne Blvd., Portland 15, Oregon
Centralab Div. Globe Union Inc., 900 E. Keefe Ave., Milwaukee 1, Wis.
Cinema Engineering Co., 1510 W. Verdugo Ave., Burbank, Calif.
Daven Co., 191 Central Ave., Newark 4, N. J.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
General Radio Co., 275 Massaschusetts Ave., Cambridge 39, Mass.
Helipot Corp., 916 Meridian Ave., South Pasadena, Calif.
International Resistance Co., 401 N. Broad St., Philadelphia 8, Pa.
Leeds & Northrup Co., 4970 Stenton Ave., Philadelphia 44, Pa.
Mallory & Co., Inc., P. R. 3029 E. Washington St., Indianapolis 6, Ind.
Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne & Roberts Aves., Philadelphia 44, Pa. ADV. PG. 88.
North American Philips Co., Inc., 100 E. 42nd St., New York 17, N. Y.
Sound Apparatus Co., Stirling, N. J.
Tech Laboratories, Inc., Bergen & Edsall Blvds., Palisades Park, N. J.
Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.

POWER SUPPLIES

American Electric Motors, Inc., 4811–13 Telegraph Rd., Los Angeles, Calif.
American Electroneering Co., 2112 S. La Brea Ave., Los Angeles, Calif.
American Television & Radio Co., 300 E. Fourth St. St. Paul 1, Minn.
Atomic Instrument Co., 84 Massachusetts Ave., Cambridge 39, Mass. ADV. PG. 101.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Beta Electric Corp., 333 E. 103rd St., New York 29, N. Y.

Power Supplies

Bracke-Seib X-Ray Co., Inc., 293 Third Ave., New York 10, N. Y.
Carnine & Bitter, 2332 Ontario Rd, NW, Washington 9, D. C.
Chatham Electronics Corp., 475 Washington St., Newark 2, N. J.
Communication Devices Co., 2331 Twelfth Ave., New York 27, N. Y.
Condenser Products Co., 1375 N. Branch St., Chicago 22, Ill.
Consolidated Engineering Corp., 620 N. Lake Ave., Pasadena 4, Calif. ADV. PG. 82.
Coral Designs Div., Henry G. Dietz Co., 12–16 Astoria Blvd., Long Island City 2, N. Y.
Cossor (Canada) Ltd., 301 Windsor St., Halifax, N. S. Canada
Douglas Radio Labs., 176 Norfolk Ave., Boston 19, Mass.
Eberbach & Son Co., Inc., Ann Arbor, Mich.
Electronic Associates, Inc., Long Branch, N. J.
Electro Products Labs., Inc., 4501 N. Ravenwood, Chicago 6, Ill.
Electronic Engineering Corp., 624 Ridge Rd., Lyndhurst, N. J.
Electronic Measurements Co., Red Bank, N. J.
Electronic Products Co., 111 E. 3rd St., Mt. Vernon, N. Y.
Electronic Tube Corp., 1200 E. Mermaid Lane, Philadelphia 18, Pa.
Electronic Workshop, Inc., 351 Bleecker St., New York 14, N. Y.
Eltron, Inc., 407 N. Jackson St., Jackson, Mich.
El-Tronics, Inc., 2649 N. Howard St., Philadelphia 33, Pa. ADV. PG. 76, 77.
Embassy Engineering Corp., 224 E. 204th St., New York 58, N. Y.
Fairchild Recording Equipment Corp., 154th St. and 7th Ave., Whitestone, N. Y.
Fluke Engineering Co., John, Box 755, Springdale, Conn.
Freed Transformer Co., Inc., 1736 Weirfield St., Brooklyn 27, N. Y.
Furst Electronics, 20 S. Jefferson St., Chicago 6, Ill.
Gaveco Labs., Inc., 2 East End Ave., New York 21, N. Y.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
General Electric Co., Electronics Dept., Electronics Park, Syracuse, N. Y. ADV. PGS. 65 to 72.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Hastings Instrument Co., Box 1275, Hampton, Va.
Highland Engineering Co., 32 Holman Blvd., Hicksville, N. Y.
Huggins Laboratories, 734 Hamilton Ave., Menlo Park, Calif.
Inductograph Laboratory, Box 76, Brookfield, Conn.
Inductograph Products, 236 W. 55th St., New York, N. Y.
Industrial Electronics, Inc., 8060 Wheeler St., Detroit 10, Mich.
Interelectronics Corp., 2432 Grand Concourse, New York 57, N. Y.
James Vibrapowr Co., 3224 Armitage Ave., Chicago 47, Ill.
Kepco Labs., Inc., 149–14 41st Ave., Flushing, N. Y.
Leland Instruments, Ltd., 22–23 Millbank, London, S. W. 1
MacLeod & Hanopol, Inc., 10 Joiner St., Charleston 29, Mass.
Maurer, Inc., J. A., 37–01 31st St., Long Island City, N. Y.
Mellaphone Corp., Rochester 2, N. Y.
Millen Mfg. Co., James, 150 Exchange St., Malden, Mass.
Model Rectifier Corp., 1510 Nostrand Ave., Brooklyn 26, N. Y.
Moulic Specialities Co., 1005 W. Washington St., Bloomington, Ill.

Power Supplies

Network Mfg. Corp., Bayonne, N. J.
New London Instrument Co., P. O. Box 189, New London, Conn.
Nuclear Instrument & Chemical Corp., 223 W. Erie St., Chicago 10, Ill. ADV. PG. Back Cover.
Nuclear Measurements Corp., 3339 Central Ave., Indianapolis, Ind. ADV. PG. 96, 97.
Opad-Green Co., 71 Warren St., New York 7, N. Y.
Oregon Electronic Mfg. Co., 206 S. W. Washington St., Portland 4, Ore. ADV. PG. 104.
Pioneer Electronic Corp., 2230 Broadway, Santa Monica, Calif.
Polarad Electronics Corp., 100 Metropolitan Ave., Brooklyn 11, N. Y.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Radio Corp. of America, RCA Victor Div., Engineering Products Dept., Front & Cooper Sts., Camden, N. J. ADV. PG. 95.
Sorensen & Co., Inc., 375 Fairfield Ave., Stamford, Conn. ADV. PG. 90.
Southwestern Industrial Electronic Co., 2831 Post Oak Rd., Houston 19, Texas
Spencer-Kennedy Labs., Inc., 186 Massachusetts Ave., Cambridge 39, Mass. ADV. PG. 92.
Standard Transformer Corp., 3580 Elston Ave., Chicago 18, Ill.
Stephens Mfg. Corp., 8538 Warner Drive, Culver City, Calif.
Superior Electric Co., The, 83 Laurel St., Bristol, Conn. ADV. PG. 109.
Teletronics Laboratory, Inc., 352 Maple Ave., Westbury, N. Y.
Ther Electric & Machine Works, 15 S. Jefferson St., Chicago 6, Ill.
Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa.

POWER SUPPLIES—High Voltage

American Electroneering Co., 2112 S. La Brea Ave., Los Angeles, Calif.
American Television & Radio Co., 300 E. Fourth St., St. Paul 1, Minn.
Applied Science Corp., of Princeton, P. O. Box 44, Princeton, N. J.
Arlington Electric Products, Inc., 500 W. 52nd St., New York 19, N. Y.
Atomic Instrument Co., 84 Massachusetts Ave., Cambridge 39, Mass. ADV. PG. 101.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Berkeley Scientific Co., 6th & Nevin Ave., Richmond, Calif.
Beta Electric Corp., 333 E. 103rd St., New York 29, N. Y.
Bracke-Seib X-Ray Co., 293 Third Ave., New York 10, N. Y.
Carnine & Bitter, 2332 Ontario Rd., NW, Washington 9, D. C.
Chatham Electronics Corp., 475 Washington St., Newark 2, N. J.
Communication Devices Co., 2331 Twelfth Ave., New York 27, N. Y.
Condenser Products Co., 1375 N. Branch St., Chicago 22, Ill.
Cossor (Canada) Ltd., 301 Windsor St., Halifax, N. S., Canada
Douglas Radio Labs., 176 Norfolk Ave., Boston 19, Mass.
Electronic Associates, Inc., Long Branch, N. J.
Electronic Engineering Corp., 624 Ridge Rd., Lyndhurst, N. J.
Electronic Measurements Co., Red Bank, N. J.
Electronic Products Co., 111 E. 3rd St., Mt. Vernon, N. Y.
Eltron, Inc., 407 N. Jackson St., Jackson, Mich.
El-Tronics, Inc., 2649 N. Howard St., Philadelphia 33, Pa. ADV. PG. 76, 77.

Power Supplies

Embassy Engineering Corp., 224 E. 204th St., New York 58, N. Y.
Engineering Laboratories, Inc., 620 E. Fourth St., Tulsa 3, Okla.
Fleming Radio (Developments) Ltd., 18–20 Lonsdale St., London, E. C. 1
Fluke Engineering Co., John, Box 755, Springdale, Conn.
Furst Electronics, 20 S. Jefferson St., Chicago 6, Ill.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
General Electric Co., Electronics Dept., Electronics Park, Syracuse, N. Y. ADV. PGS. 65 to 72.
Hewlett-Packard Co., 395 Page Mill Rd., Palo Alto, Calif.
Highland Engineering Co., 32 Holman Blvd., Hicksville, N. Y.
Inductograph Laboratory, Box 76, Brookfield, Conn.
Inductograph Products, 236 W. 55th St., New York, N. Y.
Interelectronics Corp., 2432 Grand Concourse, New York 57, N. Y.
Kepco Labs., Inc., 149–14 41st Ave., Flushing, N. Y.
Leland Instruments, Ltd., 22–23 Millbank, London S. W. 1.
Mallaphone Corp., Rochester 2, N. Y.
Model Rectifier Corp., 1510 Nostrand Ave., Brooklyn, N. Y.
Moulic Specialties Co., 1005 W. Washington St., Bloomington, Ill.
Mullard Overseas Ltd., Century House, Shaftesbury Ave., London, W. C. 2
Network Mfg. Corp., Bayonne, N. J.
New London Instrument Co., P. O. Box 189, New London, Conn.
Nuclear Instrument & Chemical Corp., 223 W. Erie St., Chicago 10, Ill. ADV. PG. Back Cover.
Nuclear Measurements Corp., 3339 Central Ave., Indianapolis, Ind. ADV. PG. 96, 97.
Nucleonic Corp. of America, 497 Union St., Brooklyn 31, N. Y.
Pioneer Electronic Corp., 2230 Broadway, Santa Monica, Calif.
Polarad Electronics Corp., 100 Metropolitan Ave., Brooklyn 11, N. Y.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Radioactive Products, Inc., 3201 E. Woodbridge St., Detroit 7, Mich.
Radio Corp. of America, RCA Victor Div., Engineering Products Dept., Front & Cooper Sts., Camden, N. J. ADV. PG. 95.
Sorensen & Co., Inc., 375 Fairfield Ave., Stamford, Conn. ADV. PG. 90.
Spellman Television Co., Inc., 3029 Webster Ave. Bronx 67, N. Y. ADV. PG. 106.
Stephens Mfg. Corp., 8538 Warner Drive, Culver City, Calif.
Technical Associates, Inc, 3730 San Fernando Rd., Glendale 4, Calif. ADV. PG. 94.
Teletronics Laboratory, Inc., 352 Maple Ave., Westbury, N. Y.
Ther Electric & Machine Works, 15 S. Jefferson St., Chicago 6, Ill.
Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa.

POWER SUPPLIES—Regulated

American Electric Motors, Inc., 4811–13 Telegraph Rd., Los Angeles, Calif.
American Electroneering Co., 2112 S. La Brea Ave., Los Angeles, Calif.
American Television & Radio Co., 300 E. Fourth St., St. Paul 1, Minn.
Applied Science Corp. of Princeton, P. O. Box 44, Princeton, N. J.
Arlington Electric Products, Inc., 500 W. 52nd St., New York 19, N. Y.

Power Supplies

Atomic Instrument Co., 84 Massachusetts Ave., Cambridge 39, Mass. ADV. PG. 101.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Beckman & Whitley, Inc., 985 San Carlos Ave., San Carlos, Calif.
Beta Electric Corp., 333 E. 103rd St., New York 29, N. Y.
Bracke-Seib X-Ray Co., Inc., 293 Third Ave., New York 10, N. Y.
Carnine & Bitter, 2332 Ontario Rd., NW, Washington 9, D. C.
Chatham Electronics Corp., 475 Washington St., Newark 2, N. J.
Cinema-Television, Ltd., Worsley Bridge Rd., London, S. E. 26
Condenser Products Co., 1375 N. Branch St., Chicago 22, Ill.
Douglas Radio Labs., 176 Norfolk Ave., Boston 19, Mass.
Electronic Associates, Inc., Long Branch, N. J.
Electronic Engineering Co., 624 Ridge Rd., Lyndhurst, N. J.
Electronic Measurements Co., Red Bank, N. J.
Electronic Workshop, Inc., 351 Bleecker St., New York 14, N. Y.
Eltron, Inc., 407 N. Jackson St., Jackson, Mich.
El-Tronics, Inc., 2649 N. Howard St., Philadelphia 33, Pa. ADV. PG. 76, 77.
Engineering Laboratories, Inc., 620 E. Fourth St., Tulsa 3, Okla.
Fairchild Recording Equipment Corp., 154th St. & 7th Ave., Whitestone, N. Y.
Fleming Radio (Developments) Ltd., 18–20 Laystall St., London, E. C. 1
Fluke Engineering Co., John, Box 755, Springdale, Conn.
Freed Transformer Co., Inc., 1736 Weirfield St., Brooklyn 27, N. Y.
Furst Electronics, 20 S. Jefferson St., Chicago 6, Ill.
Gaveco Labs., Inc., 2 East End Ave., New York 21, N. Y.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
General Electric Co., Electronics Dept., Electronics Park, Syracuse, N. Y. ADV. PGS. 65 to 72.
Hastings Instrument Co., Box 1275, Hampton, Va.
Highland Engineering Co., 32 Holman Blvd., Hicksville, N. Y.
Inductograph Laboratory, Box 76, Brookfield, Conn.
Inductograph Products, 236 W. 55th St., New York, N. Y.
Industrial Electronics, Inc., 8060 Wheeler St., Detroit 10, Mich.
Industrial Science Associates, 542 Fifth Ave., New York 19, N. Y.
Kepco Labs., Inc., 149–14 41st Ave., Flushing, N. Y.
Lambda Electronics Corp., 103–02 Northern Blvd., Corona, N. Y. ADV. PG. 100.
Leland Instruments, Ltd., 22–23 Millbank, London, S. W. 1
MacLeod & Hanopol, Inc., 10 Joiner St., Charlestown 29, Mass.
Mellaphone Corp., Rochester 2, N. Y.
Millen Mfg. Co., James, 150 Exchange St., Malden, Mass.
Model Rectifier Corp., 1510 Nostrand Ave., Brooklyn, N. Y.
Moulic Specialties Co., 1005 W. Washington St., Bloomington, Ill.
Network Mfg. Corp., Bayonne, N. J.
New London Instrument Co., P.O. Box 189, New London, Conn.
Nuclear Instrument & Chemical Corp., 223 W. Erie St., Chicago 10, Ill. ADV. PG. Back Cover.
Nuclear Measurements Corp., 3339 Central Ave., Indianapolis, Ind. ADV. PG. 96, 97.
Opad-Green Co., 71 Warren St., New York 7, N. Y.

Pumps

Oregon Electronic Mfg. Co., 206 S. W. Washington St., Portland 4, Ore. ADV. PG. 104.
Polarad Electronics Corp., 100 Metropolitan Ave., Brooklyn 11, N. Y.
Process & Instruments, 60 Greenpoint Ave., Brooklyn 22, N. Y.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Radio Corp. of America, RCA Victor Div., Engineering Products Dept., Front & Cooper Sts., Camden, N. J. ADV. PG. 95.
Radioactive Products, Inc., 3201 E. Woodbridge St., Detroit 7, Mich.
Servomechanisms, Inc., 142 Mineola Blvd., Mineola, N. Y. ADV. PG. 80.
Sorensen & Co., Inc., 375 Fairfield Ave., Stamford, Conn. ADV. PG. 90.
Southwestern Industrial Electronic Co., 2831 Post Oak Rd., Houston 19, Texas
Spellman Television Co., Inc., 3029 Webster Ave., Bronx 67, N. Y. ADV. PG. 106.
Spencer-Kennedy Labs., Inc., 186 Massachusetts Ave., Cambridge 39, Mass. ADV. PG. 92.
Superior Electric Co., The, 83 Laurel St., Bristol, Conn. ADV. PG. 109.
Technical Associates, Inc., 3730 San Fernando Rd., Glendale 4, Calif. ADV. PG. 94.
Teletronics Laboratory, Inc., 352 Maple Ave., Westbury, N. Y.
Ther Electric & Machine Works, 15 S. Jefferson St., Chicago 6, Ill.
Western Sound & Electric Labs., Inc., 805 S. Fifth St., Milwaukee 4, Wis.
Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa.

PRESSES—Laboratory

American Steel Foundries, Elmes Engineering Division, 1150 Tennessee Ave., Cincinnati 29, Ohio
Denison Engineering Co., 1186 Dublin Rd., Columbus, Ohio
Fisher Mfg. Co., Inc., John C., 37–29 9th St., Long Island City 4, N. Y.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.

PUMPS—Centrifugal Vacuum

Central Scientific Co., 1700 Irving Park Rd., Chicago 13, Ill.
Consolidated Siphon Supply Co., 24 Wooster St., New York, N. Y.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Kruger & Blind Co., 511 Master St., Philadelphia, Pa.
Nukem Products Corp., 111 Colgate Ave., Buffalo 20, N. Y.
Thomsen & Sons, L. C., Kenosha, Wis.
Trane Co., La Crosse, Wis.
Worthington Pump & Machinery Corp., 426 Worthington Ave., Harrison, N. J.

PUMPS—Vacuum

Allis-Chalmers Mfg. Co., 864 S. 70th St., Milwaukee 1, Wis.
Beach-Russ Co., 44 Church St., New York 7, N. Y.
Consolidated Siphon Supply Co., 24 Wooster St., New York, N. Y.
Distillation Products Industries, Div., of Eastman-Kodak Co., 755 Ridge Rd., W., Rochester 3, N. Y.
Eitel-McCullough, Inc., San Bruno, Calif.
Foster Pump Works, Inc., 50 Washington & Front Sts., Brooklyn 1, N. Y.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Kinney Mfg. Co., 3614 Washington St., Boston, Mass.
Litton Industries, San Carlos, Calif.

Pyrometers

National Research Corp., 70 Memorial Drive, Cambridge 42, Mass.
Optical Film Engineering Co., 2125 Cherry St., Philadelphia 3, Pa.
Scientific Glass Apparatus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.
Sutorbilt Corp., Sutorbilt Bldg., 2008 E. Stauson Ave., Los Angeles, Calif.
Welch Scientific Co., W. M., 1515 Sedgwick St., Chicago 10, Ill.
Worthington Pump & Machinery Corp., 426 Worthington Ave., Harrison, N. J.

PYROMETERS

Foxboro Co., 86 Neponset Ave., Foxboro, Mass.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
J B T Instruments, Inc., 441 Chapel St., New Haven 8, Conn.
Leeds & Northrup Co., 4970 Stenton Ave., Philadelphia 44, Pa.
Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne & Roberts Aves., Philadelphia 44, Pa. ADV. PG. 88.
Pyrometer Instrument Co., Inc., Bergenfield, N. J.
Thwing-Albert Instrument Co., 5351 Pulaski Ave., Philadelphia 44, Pa.
Weston Electric Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.

RECORDERS—Fluid Flow

Austin Co., Special Devices Div., 19 Rector St., New York 6, N. Y.
Autocall Co., The, Shelby, Ohio
Automatic Temperature Control Co., Inc., 5206 Pulaski Ave., Philadelphia 44, Pa.
Bailey Meter Co., 1044 Ivanhoe Rd., Cleveland 10, Ohio
Bunnell & Co., J. H., 81 Prospect St., Brooklyn, N. Y.
Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.
Fielden Instrument Corp., 2920 N. 4th St., Philadelphia 33, Pa.
Fischer & Porter Co., 50 County Line Rd., Hatboro, Pa.
Foxboro Co., 86 Neponset Ave., Foxboro, Mass.
Gaveco Labs., Inc., 2 East End Ave., New York 21, N. Y.
Infilco, Inc., P. O. Box 5033, Tucson, Ariz.
Leeds & Northrup Co., 4970 Stenton Ave., Philadelphia 44, Pa.
Leupold & Stevens Instruments, Inc., 4445 N.E. Glisan St., Portland 13, Ore.
Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne & Roberts Aves., Philadelphia 44, Pa. ADV. PG. 88.
Phoenix Precision Instrument Co., 3803 N. 5th St., Philadelphia, Pa.
Precision Scientific Co., 3737 Cortland Ave., Chicago, Ill.
Tagliabue Instruments Div. of Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.
Taylor Instrument Co., 95 Ames St., Rochester, N. Y.

RECORDERS—Humidity

Austin Co., Special Devices Div., 19 Rector St., New York 6, N. Y.
Fielden Instrument Corp., 2920 N. 4th St., Philadelphia 33, Pa.
Foxboro Co., 86 Neponset Ave., Foxboro, Mass.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
Johnson & Jennings Co., 803 Addison Rd., Cleveland, Ohio

Recorders

Leeds & Northrup Co., 4970 Stenton Ave., Philadelphia 44, Pa.
Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne & Roberts Aves., Philadelphia 44, Pa. ADV. PG. 88.
Powers Regulator Co., 2736 Greenview Ave., Chicago, Ill.
Serdex, Inc., 91 Cambridge St., Boston, Mass.
Servo-Tek Products Co., 4 Godwin Ave., Paterson, N. J.
Tagliabue Instruments Div. of Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.
Taylor Instrument Co., 95 Ames St., Rochester, N. J.
Thermo Instruments Co., 1066 El Camino Real, Belmont, Calif.

RECORDERS—Liquid Level

Austin Co., Special Devices Div., 19 Rector St., New York 6, N. Y.
Bailey Meter Co., 1044 Ivanhoe Rd., Cleveland 10, Ohio
Fielden Instrument Corp., 2920 N. 4th St., Philadelphia 33, Pa.
Fischer & Porter Co., 50 County Line Rd., Hatboro, Pa.
Foxboro Co., 86 Neponset Ave., Foxboro, Mass.
Infilco, Inc., P. O. Box 5033, Tucson, Ariz.
Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne & Roberts Aves., Philadelphia 44, Pa. ADV. PG. 88.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Radioactive Products, Inc., 3201 E. Woodbridge St., Detroit 7, Mich.
Tagliabue Instruments Div. of Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.
Taylor Instrument Co., 95 Ames St., Rochester, N. Y.
Thermo Instruments Co., 1066 El Camino Real, Belmont, Calif.

RECORDERS—Nuclear Radiation

Alfax Paper & Engineering Co., 40 Riverside Ave., Brockton 27, Mass. ADV. PG. 100.
Anton Electronic Labs., Inc., 1226–38 Flushing Ave., Brooklyn 6, N. Y. ADV. PG. 89.
Atomic Instrument Co., 84 Massachusetts Ave., Cambridge 39, Mass. ADV. PG. 101.
Austin Co., Special Devices Div., 19 Rector St., New York 6, N. Y.
Baldwin Instrument Co., Ltd., Brooklands Works, Dartford, Kent
Berkeley Scientific Co., 6th & Nevin Ave., Richmond, Calif.
Cinema-Television Ltd., Worsley Bridge Rd., London, S. E. 26
Cyclotron Specialties Co., Moraga 8, Calif.
Electronic Products Co., 111 E. 3rd St., Mt. Vernon, N. Y.
El-Tronics, Inc., 2649 N. Howard St., Philadelphia 33, Pa. ADV. PG. 76, 77.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
Kelley-Koett Instrument Co., 936 York St., Cincinnati 14, Ohio. ADV. PG. Inside Back Cover.
Marconi Instruments, Ltd., 23–25 Beaver St., New York 4, N. Y.
Menlo Research Laboratory, Menlo Park, Calif.
Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne & Roberts Aves., Philadelphia 44, Pa. ADV. PG. 88.
Nuclear Instrument & Chemical Corps., 223 W. Erie St., Chicago 10, Ill. ADV. PG. Back Cover.
Nuclear Measurements Corp., 3319 Central Ave., Indianapolis, Ind. ADV. PG. 96, 97.
Nucleonic Corp. of America, 497 Union St., Brooklyn 31, N. Y.

Recorders

Potter Instrument Co., 115 Cutter Mill Rd., Great Neck, N. Y.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Radioactive Products, Inc., 3201 E. Woodbridge St., Detroit 7, Mich.
Special Instruments Laboratory, Inc., 1003 Highland Ave., Knoxville, Tenn. ADV. PG. 91.
Streeter-Amet Co., 4101 Ravenswood Ave., Chicago 13, Ill. ADV. PG. 110.
Technical Associates, Inc., 3730 San Fernando Rd., Glendale 4, Calif. ADV. PG. 94.
Technitrol Engineering Corp., 3211 Woodland Ave., Philadelphia 4, Pa.
Western Radiation Labs., 1107 W. 24th St., Los Angeles 7, Calif.

RECORDERS—Telemetering

American Electroneering Co., 2112 S. LaBrea Ave., Los Angeles, Calif.
Applied Science Corp. of Princeton, The, P. O. Box 44, Princeton, N. J.
Arlington Electric Products Inc., 500 W. 52nd St., New York 19, N. Y.
Austin Co., Special Devices Div., 19 Rector St., New York 6, N. Y.
Automatic Temperature Control Co., Inc., 5206 Pulaski Ave., Philadelphia 44, Pa.
Bailey Meter Co., 1044 Ivanhoe Road, Cleveland 10, Ohio
Carnine & Bitter, 2332 Ontario Rd., NW, Washington 9, D. C.
Cinema-Television Ltd., Worsley Bridge Rd., London, S. E. 26
Electronic Associates, Inc., Long Branch, N. J.
Fairchild Recording Equipment Corp., 154th St. & 7th Ave., Whitestone, N. Y.
Fielden Instrument Corp., 2920 N. 4th St., Philadelphia 33, Pa.
Fischer & Porter Co., 50 County Line Rd., Hatboro, Pa.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
Hathaway Instrument Co., 1315 S. Clarkson St., Denver 10, Colo.
Heiland Research Corp., 130 E. 5th Ave., Denver 9, Colo.
Industrial Electronics, Inc., 8060 Wheeler St., Detroit 10, Mich.
Kelley-Koett Instrument Co., 936 York St., Cincinnati 14, Ohio. ADV. PG. Inside Back Cover.
Leeds & Northrup Co., 4970 Stenton Ave., Philadelphia 44, Pa.
Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne & Roberts Aves., Philadelphia 44, Pa. ADV. PG. 88.
Special Instruments Laboratory, Inc., 1003 Highland Ave., Knoxville, Tenn. ADV. PG. 91.
Stancil-Hoffman Corp., 1016 N. Highland Ave., Hollywood 38, Calif.
Taylor Instrument Co., 95 Ames St., Rochester, N. Y.
Western Radiation Labs., 1107 W. 24th St., Los Angeles 7, Calif.
Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa.

RECTIFIERS—Metallic

American Television & Radio Co., 300 E. Fourth St., St. Paul 1, Minn.
Bradley Labs., Inc., 82 Meadow St., New Haven 10, Conn.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
Mallory & Co., Inc., P. R., 3029 E. Washington St., Indianapolis 6, Ind.
Mellaphone Corp., Rochester 2, N. Y.
Model Rectifier Corp., 1510 Nostrand Ave., Brooklyn 26, N. Y.

Refrigeration Equipment

Opad-Green Co., 71 Warren St., New York 7, N. Y.
Sylvania Electric Products, Inc., 1740 Broadway, New York 19, N. Y.
Thor Electric & Machine Works, 15 S. Jefferson St., Chicago 6, Ill.
Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa.

RECTIFIERS—Tube Rectifying Units

American Communications Corp., 306 Broadway, New York 7, N. Y.
American Television & Radio Co., 300 E. Fourth St., St. Paul 1, Minn.
Amperex Electronic Corp., 25 Washington St., Brooklyn 1, N. Y.
Furst Electronics, 20 S. Jefferson St., Chicago 6, Ill.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
General Electric Co., Electronics Dept., Electronics Park, Syracuse, N. Y. ADV. PGS. 65 to 72.
Thor Electric & Machine Works, 15 S. Jefferson St., Chicago 6, Ill.
Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa.

REFERENCE SOURCES & STANDARDS —Radioactive

Baldwin Instrument Co., Ltd., Brooklands Works, Dartford, Kent.
Kelley-Koett Instrument Co., 936 York St., Cincinnati 14, Ohio. ADV. PG. Inside Back Cover.
Nuclear Measurements Corp., 3339 Central Ave., Indianapolis, Ind. ADV. PG. 96, 97.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Radioactive Products, Inc., 3201 E. Woodbridge St., Detroit 7, Mich.
Technical Associates, Inc., 3730 San Fernando Rd., Glendale 4, Calif. ADV. PG. 94.
Tracerlab, Inc., 130 High St., Boston 10, Mass. ADV. PG. 74, 75.
U. S. Radium Corp., 535 Pearl St., New York 7, N. Y.
Victoreen Instrument Co., 3800 Perkins Ave., Cleveland, Ohio. ADV. PG. Inside Front Cover.
Well Surveys, Inc., 624 E 4th St., Tulsa 3, Okla.

REFRIGERATION EQUIPMENT

American Thermal Industries, Inc., 440 Illinois St., Detroit, Mich.
Bowser, Inc., Refrigeration Div., Terryville, Conn.
Clark Bros. Co., Inc., Lincoln Ave. & Fifth St., Olean, N. Y.
Cutler-Hammer, Inc., 412 N. 12th St., Milwaukee 1, Wis.
General Controls Co., Glendale 1, Calif.
General Electric Co., Air Conditioning Dept., Bloomfield, N. J. ADV. PGS. 65 to 72.
Harris, Inc., Machine Works, 61 S. E. Yamhill, Portland, Ore.
Jewett Refrigerator Co., 15 Letchworth St., Buffalo, N. Y.
Little, Inc., Arthur D., Cambridge 42, Mass.
McCray Refrigerator Co., Kendallville, Ind.
Marlo Coil Co., 6135 Manchester St., St. Louis, Mo.
Metrex Valve Co., Hirschberg Blvd. & Franklin Ave., Franklin Park, Ill.
Mowat Refrigerator, John 1866 Folsom, San Francisco, Calif.
Reynolds Mfg. Co., Springfield, Mo.
Rustander & Sons, Inc., 18 Letchworth St., Buffalo, N. Y.
Sherer-Gillett Co., Marshall, Mich.
Simpson Electric Co., Div. of American Gage & Machine Co., 5208 W. Kinzie St., Chicago 44, Ill. ADV. PG. 107.
Tenney Engineering, Inc., 26 Avenue B, Newark 5, N. J.

Regulators

Trane Co., La Crosse, Wis.
United States Air Conditioning Corp., Como Ave. SE at 33rd, Minneapolis 14, Minn.
U. S. Thermo Control Co., 44 S. 12th St., Minneapolis, Minn.
Vogt Machine Co., Henry, 1000 W. Ormsby St., Louisville 10, Ky.
Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa.
Wilson Refrigeration, Inc., Smyrna, Del.
Worthington Pump & Machinery Corp., 426 Worthington Ave., Harrison, N. J.
York Corp., York, Pa.

REGULATORS—Voltage

Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.
Electronic Measurements Co., Red Bank, N. J.
Ferranti Electric, Inc., 30 Rockefeller Plaza, New York 20, N. Y.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Highland Engineering Co., 32 Holman Blvd., Hicksville, N. Y.
Red Bank Division, Bendix Aviation Corp., Red Bank, N. J.
Sola Electric Co., 4633 W. 16th St., Chicago 50, Ill. ADV. PG. 78.
Sorensen & Co., Inc., 375 Fairfield Ave., Stamford, Conn. ADV. PG. 90.
Superior Electric Co., The, 83 Laurel St., Bristol, Conn. ADV. PG. 109.
Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa.

RELAYS—Sensitive

Automatic Temperature Control Co., Inc., 5206 Pulaski Ave., Philadelphia 44, Pa.
Biddle Co., James G., 1316 Arch St., Philadelphia 7, Pa.
Edison Inc., Thomas A., Instrument Div., West Orange, N. J.
General Controls Co., Glendale 1, Calif.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
General Electric Co., Electronics Dept., Electronics Park, Syracuse, N. Y. ADV. PGS. 65 to 72.
Servo-Tek Products Co., 4 Godwin Ave., Paterson 1, N. J.
Varo Mfg. Co., Box 638, Garland, Texas
Ward Leonard Electric Co., 31 South St., Mt. Vernon, N. Y.
Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.

REMOTE HANDLING DEVICES

Aeronautical Research Labs., General Mills, Inc., 2010 E. Hennepin Ave., Minneapolis 13, Minn. ADV. PG. 99.
Arlington Electric Products, Inc., 500 W. 52nd St., New York 19, N. Y.
Austin Co., Special Devices Div., 19 Rector St., New York 6, N. Y.
Conoflow Corp., 2100 Arch St., Philadelphia 3, Pa.
Gale Dorothea Mechanisms, 37-61 85th St., Jackson Heights, L. I., N. Y.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
Hannifin Corporation, 1194 S. Kilbourne Ave., Chicago 24, Ill.
Kupfrian Mfg. Co., Binghamton, N. Y.
Process & Instruments, 60 Greenpoint Ave., Brooklyn 22, N. Y.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.

Resistors

Technical Associates, Inc., 3730 San Fernando Rd., Glendale 4, Calif. ADV. PG. 94.
Tracerlab, Inc., 130 High St., Boston 10, Mass. ADV. PG. 74, 75.

RESISTORS

NOTE: Various types of resistors are not indicated in this listing. Contact manufacturer for specific type(s) desired

Allen-Bradley Co., 136 W. Greenfield Ave., Milwaukee 4, Wis.
Bird Electronic Corp., 1800 E. 38th St., Cleveland 14, Ohio
Bond Electronics Corp., 88 Franklin Pl., Summit, N. J.
Bradley Labs., 82 Meadow St., New Haven, Conn.
Brown Electro-Measurement Corp., 4637 SE Hawthorne Blvd., Portland 15, Ore.
Carborundum Co., Globar Div., Niagara Falls, N. Y.
Centralab Division, Globe-Union Inc., 900 Keefe Ave., Milwaukee 1, Wis.
Cima Corp., 91 Boylston St., Jamaica Plains 30, Mass.
Cinema Engineering Co., 1510 W. Verdugo Ave., Burbank, Calif.
Clarostat Mfg. Co., Inc., Dover, N. H.
Continental Carbon, Inc., 13900 Lorain Ave., Cleveland 11, Ohio.
Daven Co., 191 Central Ave., Newark 4, N. J.
Dejur-Amsco Corp., Northern Blvd. at 45th St., Long Island City 1, N. Y.
Electrical Reactance Corp., Elm St., Franklinville, N. Y.
Erie Resistor Corp., 644 W. 12th St., Erie, Pa.
Fairchild Camera & Instrument Corp., 88-06 Van Wyck Blvd., Jamaica 1, N. Y.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Hardwick, Hindle, Inc., 40 Herman St., Newark 5, N. J.
Helipot Corp., 916 Meridian Ave., South Pasadena, Calif.
I-T-E Circuit Breaker Co., 19th and Hamilton Sts., Philadelphia 30, Pa.
Instrument Resistors Co., 1036 Commerce Ave., Union, N. J.
International Resistance Co., 401 N. Broad St., Philadelphia 8, Pa.
Keystone Carbon Co., Inc., St. Marys, Pa.
Lectrohm, Inc., 5903 Archer Ave., Chicago 38, Ill.
Leeds & Northrup Co., 4970 Stenton Ave., Philadelphia 44, Pa.
Macdonald & Co., Inc., W. S., 33 University Rd., Cambridge 38, Mass.
Mallory & Co., Inc., P. R., 3029 E. Washington St., Indianapolis 6, Ind.
Mepco Inc., 35-37 Abbott Ave., Morristown, N. J.
Micro Circuits Co., New Buffalo, Mich.
Ohmite Mfg. Co., 4835 W. Flournoy St., Chicago 44, Ill.
Resistance Products Co., 714 Race St., Harrisburg 2, Pa.
Resistors, Inc., 5226 W. 26th St., Chicago 50, Ill.
Shallcross Mfg. Co., 10 Jackson Ave., Collingdale, Pa.
Sprague Electric Co., North Adams, Mass.
Stackpole Carbon Co., St. Marys, Pa.
Stupakoff Ceramic & Mfg. Co., Latrobe, Pa.
Victoreen Instrument Co., 3800 Perkins Ave., Cleveland, Ohio. ADV. PG. Inside Front Cover.
Ward Leonard Electric Co., 21 South St., Mt. Vernon, N. Y.
Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa.
White Dental Mfg. Co., S. S., Industrial Div., 10 East 40th St., New York 16, N. Y.

RINGS—Absorption Fractioning

Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Knight, Maurice A., 171 Kelly Ave., Akron, Ohio

RODS—Hard Rubber

Goodrich Co., B. F., 448 S. Main St., Akron, Ohio

SAMPLE HOLDERS & CHANGERS

Atomic Instrument Co., 84 Massachusetts Ave., Cambridge 39, Mass. ADV. PG. 101.
Special Instruments Laboratory, Inc., 1003 Highland Ave., Knoxville, Tenn. ADV. PG. 91.
Tracerlab, Inc., 130 High St., Boston 10, Mass. ADV. PG. 74, 75.

SCALERS

Abrams Instrument Corp., 600–620 E. Schiawassee St., Lansing, Mich.
Applied Science Corp. of Princeton, P. O. Box 44, Princeton, N. J.
Atomic Instrument Co., 84 Massachusetts Ave., Cambridge 39, Mass. ADV. PG. 101.
Berkeley Scientific Co., 6th & Nevin Ave., Richmond, Calif.
Carnine & Bitter, 2332 Ontario Rd. NW, Washington 9, D. C.
Cinema-Television Ltd., Worsley Bridge Rd., London, S. E. 26
Douglas Radio Labs., 176 Norfolk Ave., Boston 19, Mass.
El-Tronics, Inc., 2649 N. Howard St., Philadelphia 33, Pa. ADV. PG. 76, 77.
Engineering Laboratories, Inc., 620 E. Fourth St., Tulsa 3, Okla.
Flader, Inc., Fredric, North Tonawanda, N. Y.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
General Electric Co., Electronics Dept., Electronics Park, Syracuse, N. Y. ADV. PGS. 65 to 72.
Hewlett-Packard Co., 395 Page Mill Rd., Palo Alto, Calif.
Kelley-Koett Instrument Co., 936 York St., Cincinnati 14, Ohio. ADV. PG. Inside Back Cover.
Marconi Instruments, Ltd., 23–25 Beaver St., New York 4, N. Y.
Nuclear Development Laboratory, P. O. Box 7034, Kansas City, Mo.
Nuclear Instrument & Chemical Corp., 223 W. Erie St., Chicago 10, Ill. ADV. PG. Back Cover.
Nuclear Measurements Corp., 3339 Central Ave., Indianapolis, Ind. ADV. PG. 96, 97.
Nucleonic Corp. of America, 497 Union St., Brooklyn 31, N. Y.
Potter Instrument Co., 115 Cutter Mill Rd., Great Neck, N. Y.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Radioactive Products, Inc., 3201 E. Woodbridge St., Detroit 7, Mich.
Southwestern Industrial Electronic Co., 2831 Post Oak Rd., Houston 19, Texas
Technical Associates, Inc., 3730 San Fernando Rd., Glendale 4, Calif. ADV. PG. 94.
Tracerlab, Inc., 130 High St., Boston 10, Mass. ADV. PG. 74, 75.

SCALES—Laboratory

Becker Division, Christian, Torsion Balance Co., Clifton, N. J.
Central Scientific Co., 1700 Irving Park Rd., Chicago 13, Ill.
Colloid Equipment Co., Inc., 48 Church St., New York, N. Y.
Eberbach & Son Co., Inc., Ann Arbor, Mich.

Silicone Grease

El-Tronics, Inc., 2649 N. Howard St., Philadelphia 33, Pa. ADV. PG. 76, 77.
Exact Weight Scale Co., 17 W. 5th Ave., Columbus, Ohio
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Humboldt Mfg. Co., 2016 N. Whipple, Chicago, Ill.
Scientific Glass Apparatus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.
Streeter-Amet Co., 4101 Ravenswood Ave., Chicago 13, Ill. ADV. PG. 110.
Troemner, Henry, 909 Arch St., Philadelphia, Pa.

SCREENS—Laboratory

Allis-Chalmers Mfg. Co., 864 S. 70th St., Milwaukee 1, Wis.
Andel & Co., Inc., 5218 N. Kedzie Ave., Chicago, Ill.
Central Scientific Co., 1700 Irving Park Rd., Chicago 13, Ill.
Consolidated Siphon Supply Co., 24 Wooster St., New York, N. Y.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Humboldt Mfg. Co., 2016 N. Whipple, Chicago, Ill.
Newark Wire Cloth Co., Newark, N. J.
Precision Scientific Co., 3737 Cortland Ave., Chicago, Ill.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Scientific Glass Apparatus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.

SCREENS, SIEVES, SHAKERS

Belke Mfg. Co., 947 N. Cicero Ave., Chicago 51, Ill.
Central Scientific Co., 1700 Irving Park Rd., Chicago 13, Ill.
Consolidated Siphon Supply Co., 24 Wooster St., New York, N. Y.
Emerson-Sack-Warner Corp., 92 Beverly, Boston, Mass.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
Humboldt Mfg. Co., 2016 N. Whipple, Chicago, Ill.
Jeliff Mfg. Corp., C. O., 122 Pequot Ave., Southport, Conn.
Newark Wire Cloth Co., Newark, N. J.
Precision Scientific Co., 3737 Cortland Ave., Chicago, Ill.
Walsted Machine Co., 2522 S. Sheridan, Tacoma 3, Wash.

SERVOMECHANISMS

See Controls, Servo

SHEETS—Hard Rubber

Goodrich & Co., B. F., 448 S. Main St., Akron, Ohio
Luzerne Rubber Co., Dewey St., Trenton, N. J.

SHOWERS—Emergency

Benson & Associates, Inc., Box 7542, Chicago, Ill.
Bristol Metal Products Corp., Bristol, Tenn.
Bullard Co., E. D., 275 Eighth St., San Francisco 3, Calif.
Powers Regulator Co., 2736 Greenview Ave., Chicago, Ill.

SILICONE GREASE

Acushnet Rubber Co., New Bedford, Mass.
Connecticut Hard Rubber Co., New Haven, Conn.
Dow Chemical Co., Midland, Mich.
Dow Corning Corp., Midland, Mich.
General Electric Co., Chemical Dept., Pittsfield, Mass. ADV. PGS. 65 to 72.

SILICONE RUBBER

Acushnet Rubber Co., New Bedford, Mass.
Connecticut Hard Rubber Co., New Haven, Conn.
Dow Chemical Co., Midland, Mich.
Dow Corning Corp., Midland, Mich.
General Electric Co., Chemical Dept., Pittsfield, Mass. ADV. PGS. 65 to 72.

SINKS—Acid Proof

Blickman, Inc., S., 7900 Gregory Ave., Weehawken, N. J. ADV. PG. 2.
Bristol Metal Products Corp., Bristol, Tenn.
Brooklyn Hospital Equipment Co., Inc., 196 Lexington Ave., New York, N. Y.
Buttling-Padgett Co., Inc., 830 Whittier, New York, N. Y.
Consolidated Siphon Supply Co., 24 Wooster St., New York, N. Y.
Emerson-Sack-Warner Corp., 92 Beverly, Boston, Mass.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
General Electric X-Ray Corp, 4855 Electric Ave., Milwaukee, Wis. ADV. PG. 73.
Houston Blow Pipe & Sheet Metal Works, P. O. Box 1692, Houston 1, Texas
Kewanee Mfg. Co., 5083 S. Center St., Adrian, Mich.
Knight, Maurice A., 171 Kelly Ave., Akron, Ohio
Laboratory Construction Co., 1115 Holmes St., Kansas City, Mo.
Metal Products Corp., 48 W. 19th St., Weehawken, N. J.
Pacific Foundry Co., Ltd., 3100 19th St., San Francisco, Calif.
Rulon Inc., Ralph V., Second & Pike Sts., Philadelphia, Pa.
Ruslander & Sons, Inc., 18 Letchworth St., Buffalo, N. Y.
U. S. Rubber Co., Electroforming Dept., 6602 Jefferson Ave., Detroit, Mich.

SINKS—Laboratory

Blickman, Inc., S., 7900 Gregory Ave., Weehawken, N. J. ADV. PG. 2.
Bristol Metal Products Corp., Bristol, Tenn.
Brooklyn Hospital Equipment Co., Inc., 196 Lexington Ave., Brooklyn, N. Y.
Buttling-Padgett Co., Inc., 830 Whittier, New York, N. Y.
Consolidated Siphon Supply Co., 24 Wooster St., New York, N. Y.
Eimer & Amend, 635 Greenwich St., New York, N. Y.
Emerson-Sack-Warner Corp., 92 Beverly, Boston, Mass.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Kewanee Mfg. Co., 5083 S. Center St., Adrian, Mich.
Knight, Maurice A., 171 Kelly Ave., Akron, Ohio
Laboratory Construction Co., 1115 Holmes St., Kansas City, Mo.
Metal Products Corp., 48 W. 19th St., Weehawken, N. J.
Pressed & Welded Steel Products Co., Inc., 38–57 11th St., Long Island City, N. Y.
Rulon Inc., Ralph V., Second & Pike Sts., Philadelphia, Pa.
Ruslander & Sons, Inc., 18 Letchworth St., Buffalo, N. Y.

SPECTROMETERS—Mass

Consolidated Engineering Corp., 620 N. Lake Ave., Pasadena 4, Calif. ADV. PG. 82.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
North American Philips Co., Inc., 100 E. 42nd St., New York 17, N. Y.

Process & Instruments, 60 Greenpoint Ave., Brooklyn 22, N. Y.
Vacuum Electronic Engineering Co., 756 Third Ave., Brooklyn 32, N. Y.

SPECTROMETERS and SPECTROGRAPHS

American Optical Co., Southbridge, Mass.
Applied Research Labs., 4336 San Fernando Rd., Glendale 4, Calif.
Baird Associates, Inc., 33 University Rd., Cambridge 38, Mass.
Bausch & Lomb Optical Co., 635 St. Paul St., Rochester 2, N. Y.
Biddle Co., James G., 1316 Arch St., Philadelphia 7, Pa.
Farrand Optical Co., Inc., Bronx Blvd. at 238th St., New York 70, N. Y.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Gaertner Scientific Corp., 1237 Wrightswood Ave., Chicago, Ill.
Jarrell-Ash Co., 165 Newberry St., Boston 16, Mass.
Marconi Instruments, Ltd., 23–25 Beaver St., New York 4, N. Y.
Perkin-Elmer Corp., Norwalk, Conn.

SPECTROPHOTOMETERS

American Optical Co., Southbridge, Mass.
Applied Physics Corp., 30 W. Green St., Pasadena 1, Calif.
Baird Associates, Inc., 33 University Rd., Cambridge 38, Mass.
Beckman Instruments, Inc., 820 Mission St., South Pasadena, Calif. ADV. PG. 85.
Biddle Co., James G., 1316 Arch St., Philadelphia 7, Pa.
Central Scientific Co., 1700 Irving Park Rd., Chicago 13, Ill.
Coleman Instruments, Inc., Maywood, Ill.
Farrand Optical Co., Inc., Bronx Blvd. at 238th St., New York 70, N. Y.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
Jarrell-Ash Co., 365 Newberry St., Boston 16, Mass.
Leeds & Northrup Co., 4970 Stanton Ave., Philadelphia 44, Pa.
Perkin-Elmer Corp., Norwalk, Conn.
Process & Instruments, 60 Greenpoint Ave., Brooklyn 22, N. Y.
Scientific Glass Apparatus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.

STANDARDS—Gamma Ray

See Reference Sources & Standards—Radioactive

STERILIZERS

American Sterilizer Co., Erie, Pa.
Pelton & Crane Co., 632 Harper Ave., Detroit, Mich.
Wilmont Castle Co., Rochester, N. Y.

STILLS—Laboratory

Aetna Scientific Co., Second & Spring St., Everett, Mass.
American Copper & Brass Works, Cincinnati, Ohio
Brighton Copper Works, Inc., 2146 Colerain Ave., Cincinnati, Ohio
Central Scientific Co., 1700 Irving Park Rd., Chicago 13, Ill.
Colloid Equipment Co., Inc., 48 Church St., New York, N. Y.
Electric Hotpack Co., Inc., 5035 Cottman Ave., Philadelphia, Pa.

Strip Coats

Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Houston Blow Pipe & Sheet Metal Works, P. O. Box 1692, Houston, Texas
Humboldt Mfg. Co., 2016 N. Whipple, Chicago, Ill.
Laboratory Construction Co., 1115 Holmes St., Kansas City, Mo.
Pfaudler Co., East Ave. & Clark St., Rochester, N. Y.
Precision Scientific Co., 3737 Cortland Ave., Chicago, Ill.
Scientific Glass Apparatus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.

STRIP COATS

Atlas Mineral Products Co., 121 Norman St., Mertztown, Pa.
Ceilcote Co., Rockefeller Bldg., Cleveland, Ohio
Cooper Co., D. C., 1467 S. Michigan Ave., Chicago, Ill.
Gordon-Lacey Chemical Products Co., Inc., 57–02 48th St., Maspeth, N. Y.
Hollingshead Corp., R. M., Cocoon Engineering Div., 840 Cooper St., Camden, N. J.
Prufcoat Laboratories, Inc., 61 Main St., Cambridge, Mass.
United Chromium, Inc., 100 East 42nd St., New York, N. Y.

SURVEY METERS

Abrams Instrument Corp., 600–620 E. Schiawassee St., Lansing, Mich.
Anton Electronic Labs., Inc., 1226–38 Flushing Ave., Brooklyn 6, N. Y. ADV. PG. 87.
Atomic Instrument Co., 84 Massachusetts Ave., Cambridge 39, Mass. ADV. PG. 101.
Atomic Research Corp., Colorado Springs, Colo.
Baldwin Instrument Co., Ltd., Brooklands Works, Dartford, Kent.
Beckman Instruments, Inc., 820 Mission St., South Pasadena, Calif. ADV. PG. 85.
Berkeley Scientific Co., 6th & Nevin, Richmond, Calif.
Chatham Electronics Corp., 475 Washington St., Newark 2, N. J.
Cinema-Television Ltd., Worsley Bridge Rd., London, S. E. 26.
Detectron Co., 5631 Cahuenga Blvd., N. Hollywood, Calif.
Douglas Radio Labs., 176 Norfolk Ave., Boston 19, Mass.
Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.
Electronic Products Co., 111 E. 3rd St., Mt. Vernon, N. Y.
El-Tronics, Inc., 2649 N. Howard St., Philadelphia 33, Pa. ADV. PG. 76, 77.
Espey Mfg. Co., Inc., 528 E. 72nd St., New York 21, N. Y.
Fisher Research Lab., Inc., 1961 University Ave., Palo Alto, Calif.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
General Electric Co., Electronics Dept., Electronics Park, Syracuse, N. Y. ADV. PGS. 65 to 72.
Geophysical Measurement Corp., 802 Wright Bldg., Tulsa 3, Okla.
Hastings Instrument Co., Box 1275, Hampton, Va.
Kelley-Koett Instrument Co., 936 York St., Cincinnati 14, Ohio. ADV. PG. Inside Back Cover.
Lansverk Electrometer Co., Pippin Rd., Cincinnati 31, Ohio
Menlo Research Laboratory, Menlo Park, Calif.
New London Instrument Co., P.O. Box 189, New London, Conn.
Nuclear Development Laboratory, P. O. Box 7034, Kansas City, Mo.
Nuclear Instrument & Chemical Corp., 223 W. Erie St., Chicago 10, Ill. ADV. PG. Back Cover.

Technical Books

Nucleonic Corp. of America, 497 Union St., Brooklyn 31, N. Y.
Precision Radiation Instruments Inc., 5478 Wilshire Blvd., Los Angeles 36, Calif.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
Radioactive Products, Inc., 3201 E. Woodbridge St., Detroit 7, Mich.
Service Diamond Tool Co., 2505 Burdette Ave., Ferndale, Mich.
Special Instruments Laboratory, Inc., 1003 Highland Ave., Knoxville, Tenn. ADV. PG. 91.
Standard Electronics Research Corp., 2 East End Ave., New York 21, N. Y.
Sylvania Electric Products, Inc., 1740 Broadway, New York 19, N. Y.
Technical Associates, Inc., 3730 San Fernando Rd., Glendale 4, Calif. ADV. PG. 94.
Tracerlab, Inc., 130 High St., Boston 10, Mass. ADV. PG. 74, 75.
Victoreen Instrument Co., 3800 Perkins Ave., Cleveland, Ohio. ADV. PG. Inside Front Cover.
Walsted Machine Co., 2522 S. Sheridan Tacoma, 3, Wash.
Well Surveys, Inc., 624 E. 4th St., Tulsa 3, Okla.

TABLE TOPS—Laboratory

Aetna Plywood & Veneer Co., 1738 Elston Ave., Chicago, Ill.
Bar-Ray Products, Inc., 209 25th St., Brooklyn, N. Y.
Blickman, Inc., S., 7900 Gregory Ave., Weehawken, N. J. ADV. PG. 2.
Bristol Metal Products Corp., Bristol, Tenn.
Brooklyn Hospital Equipment Co., Inc., 196 Lexington Ave., Brooklyn, N. Y.
Buttling-Padgett Co., Inc., 830 Whittier, New York, N. Y.
Doehler Metal Furniture Co., Inc., 194 Lexington Ave., New York, N. Y.
Durlach Can & Iron Works, 168–7th, Brooklyn, N. Y.
Eimer & Amend, 635 Greenwich St., New York, N. Y.
Emerson-Sack-Warner Corp., 92 Beverly, Boston, Mass.
Frese Corp., Adolf, 116 W 17th St., Los Angeles, Calif.
Glenwood Mfg. Co., 2606 N. San Fernando Blvd., Burbank, Calif.
Houston Blow Pipe & Sheet Metal Works, P. O. Box 1692, Houston 1, Texas
Kewanee Mfg. Co., 5083 S. Center St., Adrian, Mich.
Laboratory Construction Co, 1115 Holmes St., Kansas City, Mo.
Pressed & Welded Steel Products Co., Inc., 38–57 11th St., Long Island City, N. Y.
Riedling & Olberg Metal Works, 10th & Chestnut, Chester, Pa.
Ruslander & Sons, Inc., 18 Letchworth St., Buffalo, N. Y.
Sylvania Electric Products, Inc., 1740 Broadway, New York 19, N. Y.
U. S. Rubber Co., Electroforming Dept., 6602 Jefferson Ave., Detroit, Mich.
Woodall Industries, Inc., Laurel, Miss.

TECHNICAL BOOKS—Publishers

Addison Wesley Press, Kendall Square, Cambridge 42, Mass.
Bender & Co., Matthew, 149 Broadway, New York 6, N. Y.
Blakiston Co., 1012 Walnut St., Philadelphia 5, Pa.
Boyce-Roche Book Co., 460 Bloomfield Ave., Montclair, N. J.
Electronics Research Publishing Co., Inc., 480 Canal St., New York 13, N. Y.
Institute of Radio Engineers, Inc., 1 E. 79th St., New York, N. Y.
Instruments Publishing Co., 921 Ridge Ave., Pittsburgh 12, Pa. ADV. PG. 84.

Telemetering Systems

McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 18, N. Y.
Murray Hill Books Inc., 232 Madison Ave., New York, N. Y.
Rider Publications Inc., John F., 480 Canal St., New York 13, N. Y.
Sams Co., Inc., Howard W., 2201 E. 46th St., Indianapolis 5, Ind.
Universal Scientific Co., Vincennes, Ind.
University of Chicago Press, 5750 Ellis Ave., Chicago 37, Ill.
Van Nostrand Co., Inc., D., 250 Fourth Ave., New York 3, N. Y.
Wiley & Sons Inc., John, 440 Fourth Ave., New York, N. Y.

TELEMETERING SYSTEMS—Electronic

Airlectron, Inc., P. O. Box 151, Caldwell, N. J.
American Electroneering Co., 2112 S. LaBrea Ave., Los Angeles, Calif.
Applied Science Corp. of Princeton, P. O. Box 44, Princeton, N. J.
Arlington Electric Products Inc., 500 W. 52nd St., New York 19, N. Y.
Austin Co., Special Devices Div., 19 Rector St., New York 6, N. Y.
Automatic Temperature Control Co., Inc., 5206 Pulaski Ave., Philadelphia 44, Pa.
Bailey Meter Co., 1044 Ivanhoe Rd., Cleveland 10, Ohio.
Carnine & Bitter, 2332 Ontario Rd. NW, Washington 9, D. C.
Cinema-Television Ltd., Worsley Bridge Rd., London, S. E. 26
Clarke Instrument Corp., 910 King St., Silver Spring, Md.
Electro-Mechanical Research, Inc., Ridgefield, Conn.
Electronic Associates, Inc., Long Branch, N. J.
El-Tronics, Inc., 2649 N. Howard St., Philadelphia 33, Pa. ADV. PG. 76, 77.
Fairchild Recording Equipment Corp., 154th St. & 7th Ave., Whitestone, N. Y.
Fielden Instrument Corp., 2920 N. 4th St., Philadelphia 33, Pa.
Fischer & Porter Co., 50 County Line Rd., Hatboro, Pa.
Flader Inc., Fredric, North Tonawanda, N. Y.
Foxboro Co., 86 Neponset Ave., Foxboro, Mass.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
General Electric Co., Electronics Dept., Electronics Park, Syracuse, N. Y. ADV. PGS. 65 to 72.
Hastings Instrument Co., Box 1275, Hampton, Va.
Highland Engineering Co., 32 Holman Blvd., Hicksville, N. Y.
Loral Electronics Corp., 794 E. 140th St., New York 54, N. Y.
Minnesota Electronics Corp., 97 E. Fifth St., St. Paul 1, Minn.
Radioactive Products, Inc., 3201 E. Woodbridge St., Detroit 7, Mich.
Stancil-Hoffman Corp., 1016 N. Highland Ave., Hollywood 38, Calif.
Standard Electronics Research Corp., 2 East End Ave., New York 21, N. Y.
Sylvania Electric Products, Inc., 1740 Broadway, New York 19, N. Y.
Teletronics Laboratory, Inc., 352 Maple Ave., Westbury, N. Y.
Transmitter Equipment Mfg. Co., Inc., 345 Hudson St., New York 14, N. Y.
Trans-Sonics, Inc., Bedford Airport, Bedford, Mass.

TELEVISION SYSTEMS—Industrial

Arlington Electric Products, Inc., 500 W. 52nd St., New York 19, N. Y.
Bace Television Corp., Green & Leuning Sts., South Hackensack, N. J.

Thermocouples

Bausch & Lomb Optical Co., 635 St. Paul St., Rochester 2, N. Y.
Bell Television, 147 West 42nd St., New York 17, N. Y.
Carnine & Bitter, 2332 Ontario Rd. NW, Washington 9, D. C.
Cinema-Television Ltd., Worsley Bridge Rd., London, S. E. 26
Douglas Radio Labs., 176 Norfolk Ave., Boston 19, Mass.
DuMont Laboratories, Inc., Allen B., Instrument Div., 1000 Main Ave., Clifton, N. J.
Loral Electronics Corp., 794 E. 140th St., New York 54, N. Y.
Marconi Instruments, Ltd., 23–25 Beaver St., New York 4, N. Y.
Photobell Company, 116 Nassau St., New York 7, N. Y.
Polarad Electronics Corp., 100 Metropolitan Ave., Brooklyn 11, N. Y.
Radio Corp. of America, RCA Victor Div., Engineering Products Dept., Front & Cooper Sts., Camden, N. J. ADV. PG. 95.
Spellman Television Co., Inc., 3029 Webster Ave., Bronx 67, N. Y. ADV. PG. 106.
Supreme, Inc., Greenwood, Miss.
Teletronics Laboratory, Inc., 352 Maple Ave., Westbury, N. Y.
Television Equipment Corp., 238 Williams St., New York, N. Y. ADV. PG. 79.

THERMOCOUPLES

American Thermo Electrical Co., 67 E. 8th St., New York 3, N. Y.
Biddle Co., James G., 1316 Arch St., Philadelphia 7, Pa.
Cambridge Instrument Co., Inc., 3786 Grand Central Terminal, New York 17, N. Y.
Cossor (Canada) Ltd., 301 Windsor St., Halifax, N. S., Canada.
Dallons Labs., 5066 Santa Monica Blvd., Los Angeles, Calif.
Farrand Optical Co., Inc., Bronx Blvd. at 238th St., New York 70, N. Y.
Foxboro Co., 86 Neponset Ave., Foxboro, Mass.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
Hastings Instrument Co., Box 1275, Hampton, Va.
Illinois Testing Labs., Inc., 420 N. LaSalle St., Chicago 10, Ill.
Industrial Controls, Inc., 525 N. Noble St., Chicago 22, Ill.
J B T Instruments Inc., 441 Chapel St., New Haven 8, Conn.
Jarrell-Ash Co., 165 Newberry St., Boston 16, Mass.
Leeds & Northrup Co., 4970 Stenton Ave., Philadelphia 44, Pa.
Lewis Engineering Co., 52 Rubber Ave., Naugatuck, Conn.
Meters, Inc., 915 Westfield Blvd., Indianapolis 20, Ind.
Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne & Roberts Aves., Philadelphia 44, Pa. ADV. PG. 88.
Nuclear Instrument & Chemical Corp., 223 W. Erie St., Chicago 10, Ill. ADV. PG. Back Cover.
Perkin-Elmer Corp., Norwalk, Conn.
Pyrometer Instrument Co., Inc., Bergenfield, N. J.
Reeder & Co., 171 Victor Ave., Detroit 3, Mich.
Richards Co., Inc., Arklay S., 12 Winchester St., Newton Highlands 61, Mass.
Sensitive Research Instrument Corp., 9 Elm Ave., Mt. Vernon, N. Y.
Simpson Electric Co., Div. of American Gage & Machine Co., 5208 W. Kinzie St., Chicago 44, Ill. ADV. PG. 107.
Tagliabue Instruments Div. of Weston Electrical In-

Thermometers

strument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.
Thwing-Albert Instrument Co., 5351 Pulaski Ave., Philadelphia 44, Pa.
Triplett Electrical Instrument Co., 286 Harmon Rd., Bluffton, Ohio
Wheelco Instruments Co., 847 W. Harrison St., Chicago 7, Ill.

THERMOMETERS—Laboratory

Central Scientific Co., 1700 Irving Park Rd., Chicago 13, Ill.
Colloid Equipment Co., Inc., 48 Church St., New York, N. Y.
Eimer & Amend, 635 Greenwich St., New York, N. Y.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Hospital Equipment Corp., 91 Madison Ave., New York, N. Y.
Humboldt Mfg. Co., 2016 N. Whipple, Chicago, Ill.
Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne & Roberts Aves., Philadelphia 44, Pa. ADV. PG. 88.
Ruehfel Co., Inc., 107–20 101st Ave., Richmond Hill, N. Y.
Scientific Glass Apparatus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.
Simpson Electric Co., Div. of American Gage & Machine Co., 5208 W. Kinzie St., Chicago 44, Ill. ADV. PG. 107.
Special Glass Products Co., 2 W. 33rd St., New York, N. Y.
Tagliabue Instruments Div. of Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.
Trans-Sonics, Inc., Bedford Airport, Bedford, Mass.
Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.

TILE—Asphalt

Armstrong Cork Co., 1010 Concord St., Lancaster, Pa.
Hachmeister-Inc., 2332 Forbes St., Pittsburgh 13, Pa.
Johns-Manville, 22 E. 40th St., New York 16, N. Y.
Lasting Products Co., 202 S. Franklintown Rd., Baltimore 23, Md.
Mastic Tile Corp. of America, Newburgh, N. Y.

TILE—Ceramic

See Flooring, Acid-proof.

TILE—Rubber

Beck & Sons, Inc., I., 355 E. 20th St., New York 3, N. Y.

TIMERS

El-Tronics, Inc., 2649 N. Howard St., Philadelphia 33, Pa. ADV. PG. 76, 77.
Nuclear Instrument & Chemical Corp., 223 W. Erie St., Chicago 10, Ill. ADV. PG. Back Cover.

TIMERS—Automatic Reset

Abrams Instrument Corp., 600–620 E. Schiawassee St., Lansing, Mich.
Airlectron, Inc., P. O. Box 151, Caldwell, N. J.
American Chronoscope Corp., 316 W. First St., Mt. Vernon, N. Y.
Atomic Instrument Co., 84 Massachusetts Ave., Cambridge 39, Mass. ADV. PG. 101.
Austin Co., Special Devices Div., 19 Rector St., New York 6, N. Y.
Automatic Temperature Control Co., Inc., 5206 Pulaski Ave., Philadelphia 44, Pa.
Carnine & Bitter, 2332 Ontario Rd. NW, Washington 9, D. C.
Colloid Equipment Co., Inc., 48 Church St., New York, N. Y.

Transformers

Cooper Co., D. C., 1467 S. Michigan Ave., Chicago Ill.
Coral Designs, Div., Henry G. Dietz Co., 12–16 Astoria Blvd., Long Island City 2, N. Y.
Cramer Co., Inc., R. W., Box 13, Centerbrook, Conn.
Douglas Radio Labs., 176 Norfolk Ave., Boston 19, Mass.
Gale Dorothea Mechanisms, 37–61 85th St., Jackson Heights, L. I., N. Y.
Gaveco Labs., Inc., 2 East End Ave., New York 21, N. Y.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
Heinicke Instrument Corp., 315 Alexander St., Rochester 4, N. Y.
Kelley-Koett Instrument Co., 936 York St., Cincinnati 14, Ohio. ADV. PG. Inside Back Cover.
Lumenite Electronic Co., 407 S. Dearborn St., Chicago 5, Ill.
Marconi Instruments, Ltd., 23–25 Beaver St., New York 4, N. Y.
Nuclear Measurements Corp., 3339 Central Ave., Indianapolis, Ind. ADV. PG. 96, 97.
Paragon Electric Company, Two Rivers, Wisconsin.
Photobell Company, 116 Nassau St., New York 7, N. Y.
Photovolt Corp., 95 Madison Ave., New York 16, N. Y. ADV. PG. 104.
Potter Instrument Co., 115 Cutter Mill Rd., Great Neck, N. Y.
Serdex, Inc., 91 Cambridge St., Boston, Mass.
Special Instruments Laboratory, Inc., 1003 Highland Ave., Knoxville, Tenn. ADV. PG. 91.
Tagliabue Instruments Div. of Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.
Technical Associates, Inc., 3730 San Fernando Rd., Glendale 4, Calif. ADV. PG. 94.
Ward Leonard Electric Co., 31 South St., Mt. Vernon, N. Y.
Wilson & Co., G. C., 2 N. Passaic Ave., Chatham, N. J.
Zenith Electric Co., 152 W. Walton St., Chicago 10, Ill.

TRANSFORMERS—Voltage Regulating

Acme Electric Corp., 31 Water St., Cuba, N. Y.
Electronic Transformer Co., Inc., 215 W. 25th St., New York, N. Y.
Ferranti Electric, Inc., 30 Rockefeller Plaza, New York 20, N. Y.
Freed Transformer Co., Inc., 1736 Weirfield St., Brooklyn 27, N. Y.
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Raytheon Mfg. Co., Equipment Sales Div., Waltham 54, Mass.
Sola Electric Co., 4633 W. 16th St., Chicago 50, Ill. ADV. PG. 78.
Sorensen & Co., Inc., 375 Fairfield Ave., Stamford, Conn. ADV. PG. 90.
Superior Electric Co., 83 Laurel St., Bristol, Conn. ADV. PG. 109.
United Transformer Co., 150 Varick St., New York 13, N. Y.
Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa.

TUBES—ELECTRON
(a) Electrometer
(b) Geiger
(c) Ignition
(d) Mass Spectrometer
(e) Photomultiplier
(f) Rectifying

Transformers

(g) Thyratron
(h) Voltage Regulating
(i) X-Ray

Allied Radio Corp., 833 W. Jackson Blvd., Chicago 7, Ill. h
American Scientific Co., P. O. Box 1, Highbridge Station, New York 52, N. Y. e
Amperex Electronic Corp., 25 Washington St., Brooklyn 1, N. Y. b-f-g-i
Anton Electronics Labs., Inc., 1226–38 Flushing Ave., Brooklyn 6, N. Y. ADV. PG. 89 b
Bradley Labs., Inc., 82 Meadow St., New Haven 10, Conn. e
Chatham Electronics Corp., 475 Washington St., Newark 2, N. J. b-f-g-h
Cinema-Television, Ltd., Worsley Bridge Rd., London, S. E. 26 b-e
Consolidated Engineering Corp., 620 N. Lake Ave., Pasadena 4, Calif. d
Cyclotron Specialities Co., Moraga 8, Calif. b
Distillation Products Industries, Div. of Eastman-Kodak Co., 755 Ridge Rd. W., Rochester 3, N. Y. b
Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J. b-f-h
Electronic Products Co., 111 E. 3rd St., Mt. Vernon, N. Y. b-g-h
El-Tronics, Inc., 2649 N. Howard St., Philadelphia 33, Pa. ADV. PG. 76, 77. b
Engineering Laboratories, Inc., 620 E. Fourth St., Tulsa 3, Okla. b
General Electric Co., Apparatus Dept., Schenectady 5, N. Y. ADV. PGS. 65 to 72. b-c-d-e
General Electric X-Ray Corp., 4855 Electric Ave., Milwaukee, Wis. ADV. PG. 73. i
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass. b
Geophysical Measurements Corp., 802 Wright Bldg., Tulsa 3, Okla. b
Heintz & Kaufman Div. of The Robert Dollar Co., 947 Broadway, Redwood City, Calif. a-b-f
Hytron Radio & Electronics Corp., Salem, Mass. f
Kelley-Koett Instrument Co., 936 York St., Cincinnati 14, Ohio. ADV. PG. Inside Back Cover. b
Machlett Laboratories, Inc., 1063 Hope St., Springdale, Conn. f-i
Manufacturers Engr. & Equip. Corp., Willow Grove, Pa. b-d
Martin Co., H. S., 1916 Greenleaf St., Evanston, Ill. b
Mullard Overseas Ltd., Century House, Shaftesbury Ave., London, W. C. 2. a-b
North American Philips Co., Inc., 100 E. 42nd St., New York 17, N. Y. b-h-i
Nuclear Development Laboratory, P. O. Box 7034, Kansas City, Mo. b
Nuclear Instrument & Chemical Corp., 223 W. Erie St., Chicago 10, Ill. ADV. PG. Back Cover. b
Nuclear Research Corp., 112 S. 16th St., Philadelphia 2, Pa. ADV. PG. 109 b
Nucleonic Corp. of America, 497 Union St., Brooklyn 31, N. Y. b
Photobell Company, 116 Nassau St., New York 7, N. Y. e
Photovolt Corp., 95 Madison Ave., New York 16, N. Y. ADV. PG. 104. e
Pioneer Electronic Corp., 2230 Broadway, Santa Monica, Calif. b-f
Process & Instruments Co., 60 Greenpoint Ave., Brooklyn 22, N. Y. d
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102. b-e
Radioactive Products, Inc., 3201 E. Woodbridge St., Detroit 7, Mich. b
Radio Corp. of America, RCA Victor Div., Tube Dept., 415 S. Fifth St., Harrison, N. J. ADV. PG. 83, 87 c-e
Raytheon Mfg. Co., Special Tube Section, 55 Chapel St., Newton 58, Mass. **ADV. PG. 112** a-b-c-g-h-i
Sylvania Electric Products, Inc., 1740 Broadway, New York 19, N. Y. b-f-g
Technical Associates, Inc., 3730 San Fernando Rd., Glendale 4, Calif. ADV. PG. 94. b
Tracerlab, Inc., 130 High St., Boston 10, Mass. **ADV. PG. 74, 75.** b
Vacuum Electronic Engineering Co., 756 Third Ave., Brooklyn 32, N. Y. d
Victoreen Instrument Co., 3800 Perkins Ave., Cleveland, Ohio. ADV. PG. Inside Front Cover. a-b-h
Western Radiation Labs., 1107 W. 24th St., Los Angeles 7, Calif. b
Westinghouse Electric Corp., Electronic Tube Sales Dept., Bloomfield, N. J. a-b-c-e-f-g-h-i
Wood Counter Laboratory, N., 5646 Harper Ave., Chicago 37, Ill. ADV. PG. 104.

Tubing

TUBING—Glass

Bache & Co., Semon, 636 Greenwich St., New York 14, N. Y.
Corning Glass Works, Corning, N. Y.
Dallons Labs., 5066 Santa Monica Blvd., Los Angeles, Calif.
Fischer & Porter Co., 50 County Line Rd., Hatboro, Pa.
Frank Bros Mfg. Co., 10 W. Houston St., New York, N. Y.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Miller, Inc., Ray, 340 Dayton St., Newark, N. J.
Mitchell-Rand Insulation Co., Inc., 51 Murray St., New York 7, N. Y.
Phoenix Precision Instrument Co., 3803 N. 5th St., Philadelphia, Pa.
Scientific Glass Apparatus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.
Special Glass Products Co., 2 W. 33rd St., New York, N. Y.

TUBING GLASS—Precision Bore

Dallons Labs., 5066 Santa Monica Blvd., Los Angeles, Calif.
Fischer & Porter Co., 50 County Line Rd., Hatboro, Pa.
Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Phoenix Precision Instrument Co., 3803 N. 5th St., Philadelphia, Pa.
Scientific Glass Apparatus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.
Special Glass Products Co., 2 W. 33rd St., New York, N. Y.

TUBING—Hard Rubber

Frese Corp., Adolf, 116 W. 17th St., Los Angeles, Calif.
Luzerne Rubber Co., Dewey St., Trenton, N. J.
Miller, Inc., Ray, 340 Dayton St., Newark, N. J.
U. S. Rubber Co., Electroforming Dept., 6602 Jefferson Ave., Detroit, Mich.

TUBING—Metal and Alloy

Aluminum Co. of America, 2156 Gulf Bldg., Pittsburgh, Pa.
Astell & Co., Inc., John B., 90 West Broadway, New York 7, N. Y.
Buttling-Padgett Co., Inc., 830 Whittier, New York, N. Y.
Carpenter Steel Co., Alloy Tube Div., Union, N. J.
Chase Brass & Copper Co., Inc., Waterbury 91, Conn.
Consolidated Siphon Supply Co., 24 Wooster St., New York, N. Y.
Globe Steel Tubes Co., Milwaukee, Wis.
Hayes Stellite Division, Union Carbide & Carbon Corp., Kokomo, Indiana.

Tubing

ternational Nickel Co., Inc., 67 Wall St., New ork 5, N. Y.
akepeace Co., D. E., Attleboro, Mass.
iller, Inc., Ray, 340 Dayton St., Newark, N. J.
ational Lead Co., 111 Broadway, New York 6, N. Y.
at & Sons, Inc., Joseph, Broad & Quarry Sts., hiladelphia, Pa.
evere Copper & Brass, Inc., 230 Park Avenue, New ork 17, N. Y.
uperior Tube Co., Norristown, Pa.

UBING—Plastic

and & Co., Wm., Willimantic, Conn.
eveland Container Co., 6201 Barberton Ave., eveland 2, Ohio.
onneaut Rubber & Plastic Co., Conneaut, Ohio
scher-Nelson Corp., 704 West North Ave., Milaukee 5, Wis.
eneral Cement Mfg. Co., 919 Taylor Ave., Rockrd, Ill.
amilton Kent Mfg. Co., Kent, Ohio
iller, Inc., Ray, 340 Dayton St., Newark, N. J.
itchell-Rand Insulation Co., Inc., 51 Murray St., ew York 7, N. Y.
ational Varnished Products Corp., 211 Randolph ve., Woodbridge, N. J.
lational Vulcanized Fibre Co., Wilmington, Del.
nn Fibre & Specialty Co., 2020 E. Westmoreland ., Philadelphia 34, Pa.
chardson Co., The, 2767 Lake St., Melrose Park, Ill.
ientific Glass Apparatus Co., Inc., 99 Lakewood errace, Bloomfield, N. J.
. S. Rubber Co., Electroforming Dept., 6602 Jefferon Ave., Detroit, Mich.
. S. Stoneware Co, The, Akron 9, Ohio.
arflex Corp., 308 N. Jay St., Rome, N. Y.

UBING—Rubber

oodrich Co, B. F., 448 S. Main St., Akron, Ohio

UBING—Seamless

luminum Co. of America, 2156 Gulf Bldg., Pittsurgh, Pa.
stell & Co., Inc., John B., 90 West Broadway, New ork 7, N. Y.
lobe Seel Tubes Co., Milwaukee, Wis.
etalsmiths, 567 White St., Orange, N. J.
iller, Inc., Ray, 340 Dayton St., Newark, N. J.
att, Jr., C. L., 35 W. Grand River, Detroit 26, ich.
evere Copper & Brass, Inc., 230 Park Ave., New ork 17, N. Y.
uperior Tube Co., Norristown, Pa.
. S. Rubber Co., Electroforming Dept., 6602 Jefferon Ave., Detroit, Mich.

UBING—Silicone Rubber

eneral Electric Co., Chemical Dept., Pittsfield, Mass. DV. PGS. 65 to 72.

UBING—Stainless

stell & Co., Inc., John B., 90 West Broadway, New ork 7, N. Y.
arpenter Steel Co., Alloy Tube Div., Union, N. J.
onsolidated Siphon Supply Co., 24 Wooster St., ew York, N. Y.
lobe Steel Tubes Co., Milwaukee, Wis.
iller, Inc., Ray, 340 Dayton St., Newark, N. J.
at & Sons, Inc., Joseph, Broad & Quarry Sts., hiladelphia, Pa.
uperior Tube Co., Norristown, Pa.

UBING—Stoneware

merica Lava Corp., Chattanooga 5, Tenn. ADV. G. 81.

Valves

Knight, Maurice A., 171 Kelly Ave., Akron, Ohio
Miller, Inc., Ray, 340 Dayton St., Newark, N. J.
Nukem Products Corp., 111 Colgate Ave., Buffalo 20, N. Y.

UTENSILS—Stainless Steel

Consolidated Siphon Supply Co., 24 Wooster St., New York, N. Y.
Durlach Can & Iron Works, 168—7th, Brooklyn, N. Y.
Emerson-Sack-Warner Corp., 92 Beverly, Boston, Mass.
Houston Blow Pipe & Sheet Metal Works, P. O. Box 1692, Houston 1, Texas
Industrial Products Engineering Co., 44–26 Hunter St., Long Island City, N. Y.
Metal Products Corp., 48 W. 19th St., Weehawken, N. J.
Miller, Inc., Ray, 340 Dayton St., Newark, N. J.
Oat & Sons, Inc., Joseph, Broad & Quarry Sts., Philadelphia, Pa.
Pressed & Welded Steel Products Co., Inc., 38–57 11th St., Long Island City, N. Y.
Ruslander & Sons, Inc., 18 Letchworth St., Buffalo, N. Y.

VALVES

See Controls.

VALVES—Control Liquid

American Valve Co., 1940 Dade, Coxsackie, N. Y.
Aquatrol, Inc., 330 Milwaukee Ave., Chicago, Ill.
Associated Valve & Engineering Co., 1150 W. Marquette Rd., Chicago 21, Ill.
Astell & Co., Inc., John B., 90 West Broadway, New York 7, N. Y.
Automatic Temperature Control Co., Inc., 5206 Pulaski Ave., Philadelphia 44, Pa.
Colloid Equipment Co., Inc., 48 Church St., New York, N. Y.
Conoflow Corp., 2100 Arch St., Philadelphia 3, Pa.
Crescent Valve Co., Hunting Park 1, Calif.
Darling Valve Mfg. Co., Walnut & Marshall Sts., Williamsport, Pa.
Fairbanks Co., 393 Lafayette St., New York, N. Y.
Fischer & Porter Co., 50 County Line Rd., Hatboro, Pa.
Foxboro Co., 86 Neponset Ave., Foxboro, Mass.
General Controls Co., Glendale 1, Calif.
Hammel-Dahl Co., 241 Richmond St., Providence, R. I.
Hamer Oil Tool Co., 29th & Gardenia, Long Beach, Calif.
Homestead Valve Mfg. Co., Box 348, Coraopolis, Pa.
Hoppe Engineering Co., 1 High, Greensboro, Ind.
Imperial Brass Mfg. Co., 1200 W. Harrison St., Chicago 7, Ill.
Imperial Bronze & Mfg. Co, Jellico, Tenn.
Keckley Co., O. C., 400 Madison St., Chicago 6, Ill.
Kieley & Meuller, Inc., North Bergen, N. J.
Klipfel Mfg. Co., Weller & Zimmerman Aves., Hamilton, Ohio.
Knowles-Fisher Corp., 1948 Industrial St., Gowanda, N. Y.
Leahy Mfg. Co., East 8th & Alameda, Los Angeles 21, Calif.
Lewis Steam Specialty & Valve Co., Cannon Ave. & Lewis St., Lansdale, Pa.
Ludlow Valve Mfg. Co., Inc., Ft. of Adams St., Troy, N. Y.
Lunkenheimer Co., Beekman St. & Waverly Ave., Cincinnati, Ohio
McAlear Mfg. Co., 1933 S. Western Ave., Chicago, Ill.
Madden & Co., P. E., 352 W Walton St., Chicago, Ill.
Metrex Valve Co., Hirschberg Blvd. & Franklin Ave., Franklin Park, Ill.

Ventilators

Miller, Inc., Ray, 340 Dayton St., Newark, N. J.
Minneapolis-Honeywell Regulator Co., 2753 Fourth Ave. S., Minneapolis, Minn.
Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne & Roberts Aves., Philadelphia 44, Pa. ADV. PG. 88.
Rockwell Co., W. S., 200 Elliott St., Fairfield, Conn.
Seattle Brass Division, Inland Empire Steel Co., P. O. Box 3164, Seattle 14, Wash.
Skinner Electric Valve Division, 137 Belden Ave., Norwalk, Conn.
Vogt Machine Co., Henry, 1000 W. Ormsbry St., Louisville 10, Ky.

VENTILATORS

Accurate Sheet Metal & Mfg. Works, 2336–38 Milwaukee Ave., Chicago 47, Ill.
Air Controls Inc., 2312 Superior Ave., Cleveland 14, Ohio
American Foundry & Furnace Co., Bloomington, Ill.
Andel & Co., Inc., 5218 N. Kedzie Ave., Chicago, Ill.
Arex Co., 4317 Ravenswood Ave., Chicago 13, Ill.
Century Fan & Ventilating Co., 47 Cedar St., Stamford, Conn.
Chelsea Fan & Blower Co., Inc., 639 South Ave., Plainfield, N. J.
Commercialaire, Inc., 302 Pacific St., Brooklyn 2, N. Y.
Dayton Electric Mfg. Co., 748 W. Adams, Chicago, Ill.
Electrovent Fan & Mfg. Co., 812 W. Lake St., Chicago 7, Ill.
Emerson-Sack-Warner Corp., 92 Beverly, Boston, Mass.
Gallaher Co., Owatonna, Minn.
Hirschman-Pohle Co., Inc., 15 Lent Ave., LeRoy, N. Y.
Houston Blow Pipe & Sheet Metal Works, P. O. Box 1692, Houston 1, Texas
Ilg Electric Ventilating Co., 2850 N. Crawford Ave., Chicago 41, Ill.
International Engineering, Inc., 1200 Bolander Ave., Dayton, Ohio
Iona Ventilator Co., Inc., 2829 W. Dauphin St., Philadelphia, Pa.
Jordan & Co., Paul R., E. South & New Jersey, Indianapolis, Ind.
Kernchen Co., 4317 Ravenswood Ave., Chicago 13, Ill.
Mine Safety Appliances Co., Braddock, Thomas & Meade Sts., Pittsburgh 8, Pa.
Minneapolis-Honeywell Regulator Co., 2753 Fourth Ave. S., Minneapolis, Minn.
Mountain States Equipment Co., 1238 Speer Blvd., Denver, Colo.
Nelson, Herman, Corp., Moline, Ill.
Pennsylvania Wire Glass Co., 1612 Market St., Philadelphia 3, Pa.
Rotron Mfg. Co., Inc., 7 Schoonmaker Lane, Woodstock, N. Y.
Small Motors, Inc., 2076 Elston Ave., Chicago 14, Ill.
Standard Ventilator Co., Lewisburg, Pa.
Swartwout Co., 18457 Euclid Ave., Cleveland, Ohio
Trane Co., La Crosse, Wis.
Unit Roof Ventilator Corp., 1225 W. Mitchell St., Milwaukee 4, Wis.
United States Air Conditioning Corp., Como Ave. SE at 33rd, Minneapolis 14, Minn.
Uno Ventilator Co., 565 Lincoln Ave., Cliftondale, Mass.
Warner Ventilator Co., LaGrange, Ind.
Western Engineering & Mfg. Co., E. Washington & Staunton, Los Angeles, Calif.

WARE—Glass & Quartz

Dallons Labs., 5066 Santa Monica Blvd., Los Angeles, Calif.

X-Ray Equipment

Milwaukee Glass Works, Inc., 2338 N. 30th St., Milwaukee, Wis.
Scientific Glass Apparatus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.
Western Gold & Platinum Works, 589 Bryant St., San Francisco, Calif.

WARE—Platinum

Pratt, Jr., C. L., 35 W. Grand River, Detroit 26, Mich.
Scientific Glass Apparatus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.
Western Gold & Platinum Works, 589 Bryant St., San Francisco, Calif.

WARE—Porcelain

American Lava Corp., Chattanooga 5, Tenn. ADV. PG. 81.
Louthan Mfg. Co., East Liverpool, Ohio
Scientific Glass Apparatus Co., Inc., 99 Lakewood Terrace, Bloomfield, N. J.

WASHERS—Laboratory Glassware

Heinicke Instrument Corp., 315 Alexander St., Rochester 4, N. Y.

WAXES

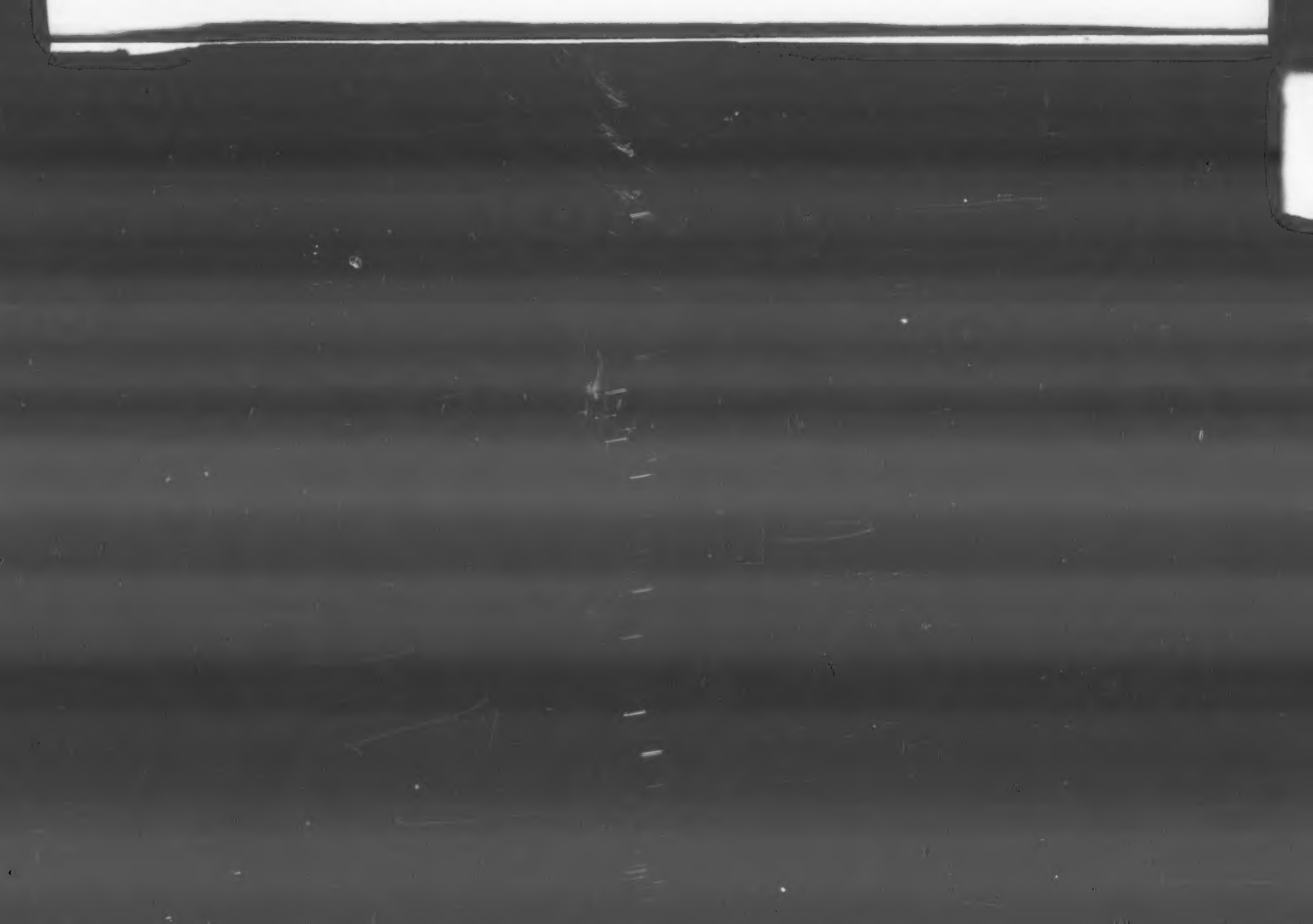
Biwax Corp., 3445 Howard St., Skokie, Ill.
General Electric Co., Chemical Dept., Pittsfield, Mass. ADV. PGS. 65 to 72.
Glyco Products Co., Inc., 26 Court St., Brooklyn 2, N. Y.
Mitchell Rand Insulation Co., Inc., 51 Murray Street, New York 7, N Y.
Zophar Mills, Inc., 112-130 26th St., Brooklyn 32, N. Y.

X-RAY DIFFRACTION APPARATUS

High Voltage Engineering Corp., 7 University Rd., Cambridge 38, Mass. ADV. PG. 103.
Jarrell-Ash Co., 165 Newberry St., Boston 16, Mass.
North American Philips Co., Inc., 100 E. 42nd St., New York 17, N. Y.
Picker X-Ray Corp., 300 Fourth Ave., New York 10, N. Y.
Waite Mfg. Division, 17235 Euclid Ave., Cleveland 12 Ohio

X-RAY EQUIPMENT—Industrial

Allis-Chalmers Mfg. Co., 864 S. 70th St., Milwaukee 1, Wis.
Bar-Ray Products, Inc., 209 25th St., Brooklyn 32, N. Y.
Bracke-Seib X-Ray Co., Inc., 293 Third Ave., New York 10, N. Y.
Farrand Optical Co., Inc., Bronx Blvd. at 238th St., New York 70, N. Y.
General Electric X-Ray Corp., 4855 Electric Ave., Milwaukee, Wis. ADV. PG. 73.
High Voltage Engineering Corp., 7 University Rd., Cambridge 38, Mass. ADV. PG. 103.
Kelley-Koett Instrument Co., 936 York St., Cincinnati 14, Ohio. ADV. PG. Inside Back Cover.
North American Philips Co., Inc., 100 E. 42nd St., New York 17, N. Y.
Picker X-Ray Corp., 300 Fourth Ave., New York 10, N. Y.
Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill. ADV. PG. 102.
St. John X-Ray Laboratory, Califon, N. J.
Victoreen Instrument Co., 3800 Perkins Ave., Cleveland, Ohio. ADV. PG. Inside Front Cover.
Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa.



EXTRA!

WIDE SENSITIVITY RANGE
DIRECT READING
RUGGED

Keleket ALPHA - BETA - GAMMA SURVEY METER

5 DIRECT-READING RANGES

This highly sensitive and accurate instrument is similar to the Keleket Gamma Survey Meter K-350 which was originally designed to rigid Signal Corps specifications. The K-351 has the added advantage of providing detection of alpha and beta radiation. A very thin (0.2 mil) window of rubber hydrochloride has been placed at the bottom of the ion chamber to pass alpha, beta, and low-energy X-radiation. A metal grill in the bottom of the case protects the thin window from damage. A snap-on metal shield is provided to stop alpha and beta radiation when gamma measurements are being made, and also to make the instrument case immersion-proof.

Model K-351

APPLICATIONS

Check contamination by radio-active materials; personal protection in radiological laboratories; measure X- or gamma radiation beam intensities; detect stray radiation from X-ray equipment; check radio-active material control setups in industrial plants; health physics surveys; radiological defense training.

SPECIFICATIONS

ACCURACY: plus or minus 10%

RANGES: **Alpha:** 0-5000, 0-50,-000, 0-500,000 d/m.
Beta: Each instrument must be calibrated for specific beta source used.
Gamma: 0-5, 0-50, 0-500, 0-5,000 0-50,-000 mr/hr. (radium gamma).

TEMPERATURE RANGE: minus 10°F. to plus 125°F.

POWER SUPPLY: Self-contained battteries.

ION CHAMBER: ¼" plastic walls, graphite coated. Alpha window of 0.2 mil pliofilm.

CASE: Grey Hammertone finish, with grill in bottom. Immersion-proof only when metal shield is in place over grill.

SIZE & WEIGHT: 10" x 6" x 5"; 10 lbs.

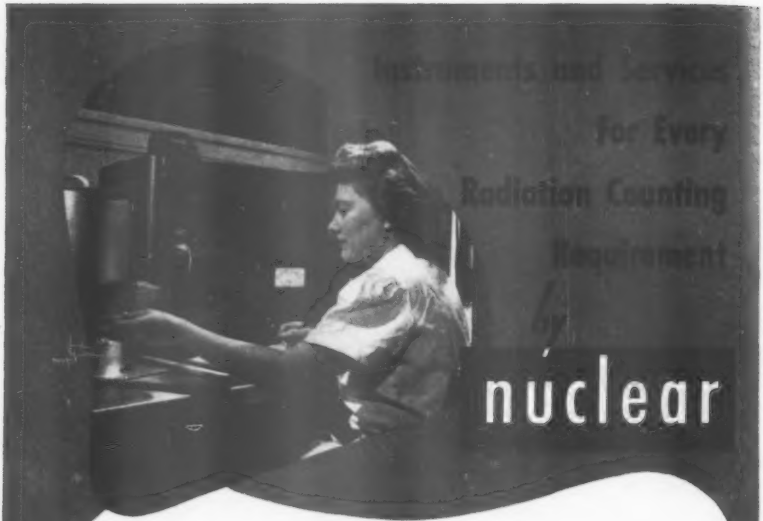
Write for literature on all KELEKET instruments

For Nuclear Instruments—Depend on the Best

The KELLEY-KOETT INSTRUMENT Co.

936-12 York St., Cincinnati 14, Ohio

Leading Manufacturer of Instruments for the Atomic Age

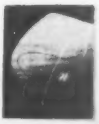


NUCLEAR INSTRUMENTS for virtually every radiation counting requirement have been developed and proved in step with the rapid progress of nuclear research. From a pen-size radiation monitor to a complete laboratory, Nuclear offers precision-made equipment of wide versatility and established performance ability.

For special techniques and unusual applications, Nuclear is ready to work with you to provide instruments to fit your requirements . . . Or to assist in development of special equipment where the need is indicated.

- **Scaling Instruments**
- **Radiation Detectors**
- **Radioactivity Demonstration Equipment**
- **Complete Counting Systems**
- **Monitoring Instruments**
- **Uranium Prospecting Units**
- **Complete accessories for the nuclear laboratory**
- **Special Instruments**

SEND FOR THIS COMPLETE CATALOG
Full data on all Nuclear Instruments and related equipment.



nuclear

235 West Erie Street, Chicago 10, Illinois, Cable Address: "Nuclear"